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Courtesy, The Ford Motor Co.

Assembly line—one of many examples of Detroit's industries that members of the A.S.M.E. will have an opportunity to inspect at the A.S.M.E. Semi-Annual Meeting, Detroit, May 17 to 20, 1937.

Volume 59
No. 5

MECHANICAL ENGINEERING

May
1937

GEORGE A. STETSON, *Editor*

Detroit in May

FEW CITIES in the United States can offer more of interest to the engineer than can Detroit. Centrally located with respect to the great industrial areas of the nation, it is easy of access to a majority of engineers. Its world-famous automobile and related industries provide unexcelled examples of mass-production manufacture, one of the great triumphs of mechanical engineering.

Realizing the unique opportunity they have to show what the automotive industries have meant to mass production and other industries all over the world, the Detroit Local Section of The American Society of Mechanical Engineers has set up a program for the 1937 Semi-Annual Meeting of the Society, in which particular emphasis has been laid on this factor. During the week of May 17, as announced in the A.S.M.E. News Section of this issue, with a combined program of planned general sessions and inspection tours, visitors will benefit from the thoughtful preparations that have been going on since the beginning of the year. They will hear from Detroit's engineers and they will see its great manufacturing plants.

A foretaste of many of the excellent technical papers to be presented at Detroit may be had by reading this and the April issue of Mechanical Engineering, and the April and May issues of the Transactions. But to get fullest benefit, attendance at Detroit will be necessary, for the unique feature of this meeting is its planned program of six keynote sessions on the mornings and evenings of Tuesday, Wednesday, and Thursday. These will be introduced by C. F. Hirshfeld in an address on Tuesday morning and summarized by Willard T. Chevalier at Thursday evening's dinner, and will afford the opportunity of hearing other men of national reputation. Seldom has so comprehensive a series of addresses been scheduled at an A.S.M.E. Meeting.

Although Detroit has been much in the public eye because of labor disputes, it is unlikely that visitors in May will see any more of strikes and strikers than they would in their own home towns. The local committee is planning a hospitable welcome and interesting programs for A.S.M.E. members and for the women who may accompany them. The committee anticipates no changes in the program because of labor troubles and no inconvenience or annoyance to visitors in the city. There will probably be as little chance of being disturbed by a strike in Detroit as there is of witnessing a hold-up or a gang murder in New York or Chicago. Plan to be in Detroit May 17 to 21. It is a typical engineer's city.

Increase Junior Activities

UNDER the membership rules of The American Society of Mechanical Engineers the grade of junior covers the period from graduation from college until the Junior member is eligible for "full" membership. During this period, in which the young man is acquiring full professional status, there are few offices or assignments to which he is not eligible, and in many parts of the country a wise policy of encouragement offers numerous opportunities for able men to participate early in their careers with more mature members in useful and gratifying work in the profession.

Notable cases of juniors as groups and as individuals taking an active and useful part in Society work have frequently been noted in Mechanical Engineering. A few recent cases may be mentioned. The list is by no means complete, but attention directed to it will, it is hoped, bring a wider realization of the opportunities the Society offers for young men to assume responsibility at an early age.

Mention has frequently been made of the Society's policy of placing junior advisers on its administrative committees. Junior groups in local sections all over the country have been organized and have indulged in a variety of useful activities. A recent example from Hartford, Conn., is a local publication known as the *Technical Times*, an eight-page bulletin under the direction of junior members. The April issue of Mechanical Engineering noted some of the activities of the Metropolitan Junior Group, such, for example, as the National Defense meeting. Programs of strictly junior-group meetings have been received from other junior groups, such as that of the Junior Division of the Tri-Cities Section.

The present issue carries on page 392 notices of other junior activities. Here are noted, for example, the joint meeting of the junior groups of the Hartford and Providence sections held at Hartford, Conn., on March 6, and the inspection trip of the Detroit Junior group, on March 28, to the Great Lakes Engineering Works. There is also published this month a report of the first year's operation of the junior group of the Ontario section, which now has a membership of thirty five, and has held several meetings at which technical papers were presented.

It is a well-known fact that many local-section executive committees have juniors among their membership active in section work. Mr. Davies reports that on a recent visit to Schenectady he found the juniors

practically in charge of the activities of the local section there. Anyone who has taken the trouble to look up the membership grades of authors of technical papers is surprised at the large percentage of juniors who are contributing to the Society's technical literature. Research activities and theoretical papers reveal a considerable number of junior members doing their part to add to the Society's prestige.

These few examples are ample testimony of the virility of an engineering society that has a policy of encouraging participation by its younger members. The problem is the wise development of the policy to increase this participation and to offer aids to a greater number. In this latter phase older members may find opportunities for satisfying and useful service. What the sections are trying to do, at the suggestion of the Engineer's Council for Professional Development, in broadening the contacts between younger and older members has been noted several times. Earnest and determined engineers have many opportunities of offering aid and encouragement to young men in their localities. A scheme that is successful in one locality may not be so in another, but, with sincere study and cooperation, each section can work out the system of personal contacts and opportunities for social as well as professional association that best fit the conditions of the section. The effort expended in bringing these associations about is decidedly worth while, and successful plans will be reported in MECHANICAL ENGINEERING if those who have had experience in their operation will take the trouble to write to headquarters about them. Let's have some letters.

E.C.P.D. Reports

THE FOURTH annual report of the Engineers' Council for Professional Development, delayed by the sudden death of Robert I. Rees while he was preparing it for publication, appeared in April. Attention has been directed from time to time to the substance of some of the individual committee reports as they were presented at the Council's annual meeting last October, but opportunity to read the complete report, with its many instructive appendixes, is now offered for the first time. The report deserves earnest study by all engineers who have the welfare of the profession at heart.

Certainly, E.C.P.D. has made a good start and has some real accomplishments to its credit, not the least of which is the impetus it has given to unity in the profession.

In various parts of the country, the Committee on Student Selection and Guidance has organized committees on vocational guidance, it has prepared a manual for the aid of these guidance committees, and it has made some encouraging progress in its study of tests of students for their engineering aptitude.

A list of accredited curricula in engineering offered by schools in the New England and Middle Atlantic states has been published by the Committee on Engineering Schools, and the work of the delegatory committees engaged in visiting and reporting on schools in other parts of the country is well under way.

Under the active and stimulating leadership of General Rees the Committee on Professional Training has issued a personal appraisal blank for junior engineers, has completed a survey on a nationwide basis of university extension courses available to young engineers, has published a general-reading list and a comprehensive technical bibliography, and has assisted in the inauguration of a program of activities for junior engineers in Providence, R. I.

A "minimum definition of an engineer" has been prepared by the Committee on Professional Recognition and its acceptance by the participating engineering societies for adoption as a minimum requirement for admission to membership has been urged. Standard grades of membership for the societies have been suggested; and statements regarding new state engineer registration laws and the amendment of existing registration laws have been proposed for approval by E.C.P.D. The committee has further urged that E.C.P.D. recommend to engineering societies "that state regulation be established as a minimum prerequisite for admission to professional grades of membership;" and it has urged greater uniformity in the engineering degree as a degree in course. (Final action on all of these points had not been taken by E.C.P.D. at the time this was written.)

Undoubtedly, the average engineer interested in the welfare of his profession will look on a majority of these works and pronounce them good. Few, for example, will find any fault with what is being done for the guidance of the student planning to enter college or for the aid to junior engineers and recent graduates commencing the practice of engineering. In general, when objectives are explained, little criticism is heard of the accrediting program of the Committee on Engineering Schools. If real assistance to the many engineer registration boards throughout the country results, the existence of a single authoritative list of accredited curricula prepared after scrupulously painstaking inquiry by nationally known engineers and educators will be of benefit to all concerned. And not the least of those benefited will be the schools themselves.

But to the rank and file of engineers who have their college and apprentice days behind them the work of the Committee on Professional Recognition comes closest to reality. Here is a group making suggestions about grades of membership and requirements for membership in engineering societies, and raising the vexatious problems involved in the registration of engineers. It will be remembered that although the reports of the Committees on Selection and Guidance, Engineering Schools, and Professional Training were received last fall with interest and commendation, adoption of the recommendations of the Committee on Professional Recognition was deferred. Suggestions on a rephrasing of one of these recommendations by the A.S.M.E. Advisory Board on Professional Status are published on page 394 of this issue. What the April meeting of the E.C.P.D. developed in regard to these recommendations it is too early to report.

Automotive Practice Influences

INDUSTRIAL BEARING DESIGN

By A. B. WILLI

CHIEF ENGINEER, FEDERAL-MOGUL CORPORATION, DETROIT, MICH.

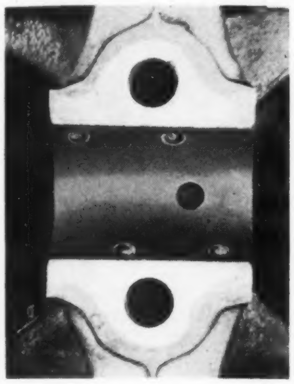


FIG. 1 ANCHOR HOLES FOR DIRECT-BABBITTED BEARING IN CAST-IRON CRANKCASE

SPLIT bearings of the type commonly used at present for main and connecting-rod bearings in an automotive engine have undergone three stages in their development. The earliest form of these bearings had the babbitt bearing metal cast directly into the cast-iron crankcase and bearing caps. Next, came the removable bearing which was made as a babbitt die casting or with the babbitt applied to a brass or bronze back. The final step in the development was the precision insert or interchangeable bearing which began to receive general acceptance slightly more than ten years ago.

Babbitt does not bond well to cast iron, and a heavy thickness was required together with dovetails or other means to provide a mechanical anchorage for the babbitt, as shown in Fig. 1. Practically no control of the babbitt structure was possible. The load-carrying ability of these early engine bearings was probably not over 500 lb per sq in. of projected area. A bearing failure was a serious and expensive repair job, entailing a complete dismantling of the engine. The repair was often poorly made because few service shops had suitable facilities for rebabbitting.

Fig. 2 shows a typical bronze-back babbitt-lined bearing installation. As first assembled, the contact faces of the bearings extended approximately $^1/_{64}$ in. beyond the corresponding case and cap surface, and a machining operation after preassembly reduced this extension to 0.002 in.

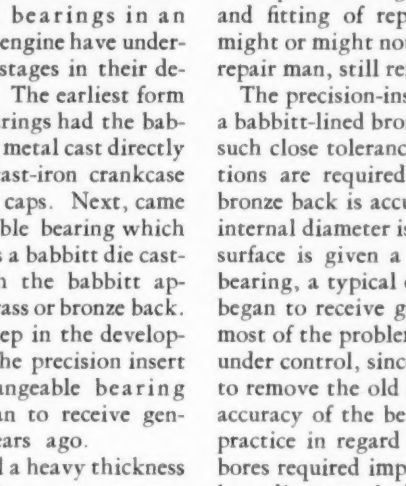


FIG. 2 EARLY TYPE OF BRONZE-BACK BABBITT-LINED MAIN BEARING

Bronze-back bearings were held in place by retainer screws; die-cast bearings usually had an integrally cast extension which served as a locating dowel. Adjustment for wear was obtained by a shim pack. Both the direct-babbitted and the removable bearing required practically the same boring and fitting operations to prepare them for the crankshaft. From a replacement standpoint, the removable bearing was a distinct improvement, since these were obtainable as factory-built parts, and, considering the bronze-backed babbitt-lined bearing particularly, the quality of the babbitt and its adhesion to the back were far superior to that of a direct-babbitted bearing poured in an inadequately equipped repair shop. The saving in time required for a complete bearing-repair job was of great importance. Boring and fitting of replacement bearings where factory accuracy might or might not be duplicated, depending on the skill of the repair man, still remained.

The precision-insert or interchangeable bearing originated as a babbitt-lined bronze-back construction. It is manufactured to such close tolerances that no boring, scraping or fitting operations are required during or after assembly.[1] The steel or bronze back is accurately ground to fit the crankcase bore, the internal diameter is manufactured to exact size, and the bearing surface is given a mirror finish by broaching. This type of bearing, a typical example of which is illustrated in Fig. 3, began to receive general acceptance about 1926, and, with it, most of the problems of service and replacement appeared to be under control, since the repairman, in theory at least, had only to remove the old and install the new bearing. To match the accuracy of the bearing and make the system workable, shop practice in regard to machining the crankcase-bearing saddle bores required improvement. Dimensional tolerances on these bore diameters had to be held within 0.001 in., and the bores must be in correct alignment and have a smooth surface finish. These requirements were met without too much trouble and, in spite of the more accurate machine work involved, important economies in engine cost were effected largely because fewer assembly operations were required. On an average, 15 operations are required to install a set of align-bored main bearings, while precision-insert bearings are installed with the maximum of five operations.

INCREASED ENGINE EFFICIENCY IMPOSED GREATER BEARING LOADS

Coincident with the evolution of a satisfactory type of bearing construction, automotive engines were becoming more and more efficient, bearing loads were heavily increased, and engine speeds stepped up. Today, the average passenger-car engine develops approximately 79 per cent more power per cubic inch of piston displacement[2] than its

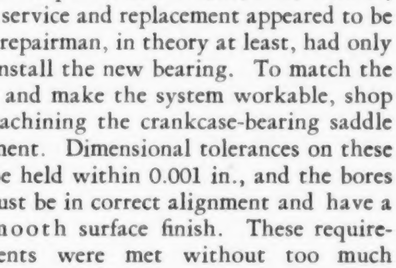


FIG. 3 TYPICAL PRECISION-INSERT (INTERCHANGEABLE) ENGINE BEARING

[1] "Developments in Bearings and Bearing Materials," by A. B. Willi, *Product Engineering*, 1937, pp. 13–15.

[2] "American Passenger Car Engine Trends," *Auto. Ind.*, 1937, p. 340.

Contributed by the Machine Shop Practice Division for presentation at the Semi-Annual Meeting, Detroit, Mich., May 17–21, 1937, of The American Society of Mechanical Engineers.

predecessor of 1925. Then, an engine which reached its peak speed at between 2800 and 3000 rpm was considered a high-speed type; today, engine speeds of from 4000 to 4500 rpm are not uncommon in passenger-car practice. About the same ratio of power-output increase is found in truck and other heavy-duty commercial-vehicle engines, and their average speed has been increased from a range of between 1100 and 1300 rpm to between 2000 and 2400 rpm and even higher.

Since bearing sizes could not be increased to any appreciable extent to carry the increased loads, improvement of bearing materials, and methods of processing, design, and lubrication were necessary. The latest type of precision-insert automotive crankshaft bearing, therefore, presents some valuable and interesting features, such as

(1) Savings in assembly time, increased production, and lowered costs.

(2) Ease of replacement and a duplication of factory accuracy when repairs are necessary.

(3) Ability to stand up and render satisfactory service for longer periods under greater loads and at higher speeds.

Modern engine bearings lined with tin-base babbitts are successfully functioning with maximum loadings of 1400 lb per sq in. of projected bearing area, and *PV*, rubbing-factor, values up to 40,000. Bearing loads far in excess of this are frequently met in engine practice, but special lining materials, such as cadmium silver, copper lead, and the like, are required if the installation is to be successful. With these, loads of 3000 lb per sq in. and *PV* values of 75,000 are possible, providing oil clearance, oil distribution in the bearing, temperature, and other contributing elements are correct.

AUTOMOTIVE-TYPE BEARINGS USED IN MACHINERY

Desirable features of the modern automotive-engine bearing and their value in machinery of many types are becoming generally recognized. In Fig. 4 is shown a group of leaded-bronze bearings used in various machines. The backs are ground, the inside diameter is diamond bored, and the wall thickness is held within a variation of 0.0005 in., while flange thickness is held within 0.002 in. They are assembled and used exactly as they come from the bearing maker with no reaming, scraping, or fitting.

Fig. 5 illustrates a group of steel-back bearings manufactured for a variety of purposes. Bearing (*a*) has a cast-steel back, and tin-base babbitt is used to line the shell and face the thrust flanges. The babbitt is applied by a process of centrifugal casting or spinning, and special attention is paid to obtaining the proper babbitt structure.

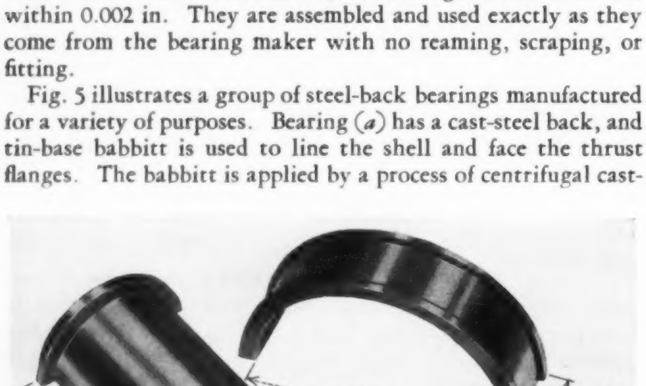


FIG. 4 LEADED-BRONZE AUTOMOTIVE-TYPE BEARINGS USED IN INDUSTRIAL MACHINERY

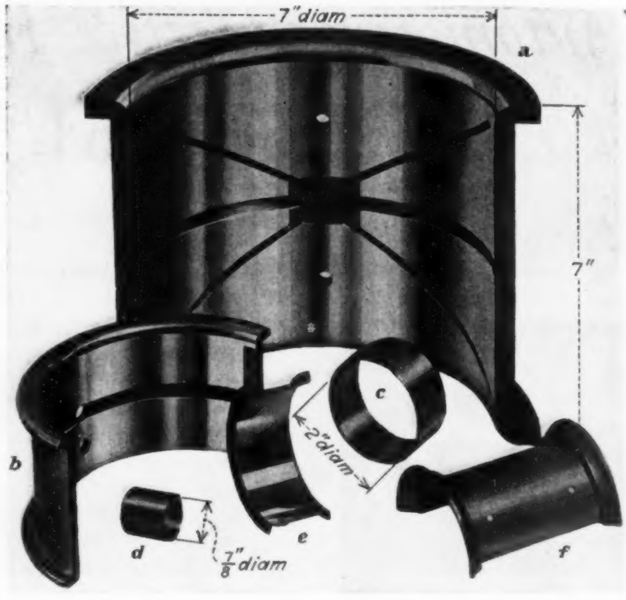


FIG. 5 TYPICAL EXAMPLES OF STEEL-BACK BEARINGS

Bearing (*b*) is of particular interest because of the high loading, 2900 lb per sq in. of projected bearing area. To carry this load successfully, a lining of cadmium silver is employed. Welded steel tubing is used for the shells of (*c*) and (*d*). The former is lined with a high-lead babbitt, and the tin-base babbitt of the latter is centrifugally cast.

Bearing (*e*) is made from thin-wall steel tubing, with the flanges die-formed. It is lined with cadmium silver. Because of the rather complicated flange form, bearing (*f*) is turned from heavy-wall tubing. The lining of this is also cadmium silver.

In all cases, the bearing surface is broached to a mirror finish, and the backs are ground to obtain perfect contact in the saddle bore.

Bronze-back babbitt-lined bearings are also made. Linings are either tin-base or high-lead babbitt. Cadmium-silver and copper-lead bearing materials are applied only to steel backs.

Many babbitt-lined bearings used in machine construction are made by hand pouring the babbitt into a cast-iron or cast-bronze shell or housing. Since tin-base babbitts do not bond well to cast iron and certain bronzes require careful treatment to obtain a good bond, mechanical means are employed for anchoring the babbitt. The babbitt is usually from $^1/_8$ to $^3/_{16}$ in. thick in the smaller bearings and from $^3/_8$ to $^1/_2$ in. thick in the larger.[3] When the metal in the anchorages is added to these thicknesses, a costly volume of babbitt is involved.

EXAMPLES OF OLD AND NEW BEARING CONSTRUCTION

Steel or bronze-back precision bearings up to 4 in. in diameter seldom have a babbitt thickness of over $^1/_{32}$ in. Bearings as large as 11 in. in diameter are successfully manufactured and used with a $^1/_{16}$-in.-thick lining. Good and dependable bonding of the lining material to the back is readily obtained and anchorages are unnecessary. The greatly reduced depth of bearing metal required in the modern bearing usually is responsible for a material saving in the finished product.

In the upper drawing of Fig. 6 is shown a typical bearing

[3] "Elements of Machine Design," by O. A. Leutwiler, McGraw-Hill Book Company, Inc., New York, N. Y., 1917, p. 515.

formerly used in the construction of a heavy-duty machine. The upper half bearing is a cast-iron shell with dovetails, into which a babbitt lining $^3/_{16}$ in. thick is poured. The lower bearing member is formed by a bronze cap, which is lined with $^3/_{16}$ in. of babbitt and has the usual anchorages. If and when a bearing failure occurs, rebabbitting and refinishing is an uncertain, lengthy, and costly proposition, with no assurance that the repair job will be of first quality. The cost of the babbitt in this bearing amounted to $1.05.

SAVING MONEY BY A NEW DESIGN

The lower sketch shows the former construction redesigned to use an insert-type bronze-back tin-base babbitt-lined bearing. Superior bonding of the babbitt to the back is obtained, and the lining thickness is reduced to $^1/_{32}$ in. The bronze back is sufficiently heavy to provide the required strength and stiffness in the bearing structure, and the bronze analysis is specifically selected to further insure a good bond. The babbitt cost in this bearing was reduced to $0.18. Due to the uniform

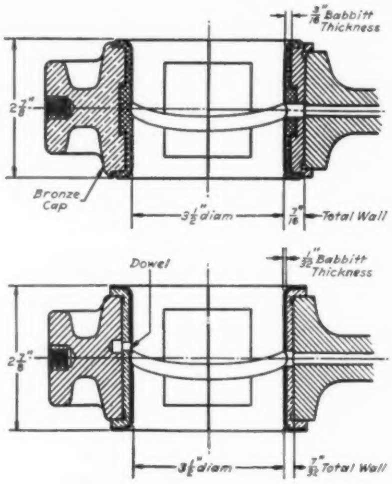


FIG. 6 BEARING FOR HEAVY-DUTY MACHINE IN WHICH WALL THICKNESS AND BABBITT LINING WERE REDUCED BY REDESIGNING

(Original design using dovetails is shown in the upper drawing, and the bearing after being redesigned to use an insert is shown underneath.)

wall thickness, the babbitt crystal structure can be controlled to obtain maximum load-carrying ability, thus materially increasing bearing life. If failure of this bearing does occur through some accident, repair is a comparatively simple matter. A replacement bearing can be installed with no machine work, scraping, or fitting, and the quality of the replacement will obviously be first class.

A somewhat different proposition was a bronze eccentric rod which operated on a steel shaft. Conditions led to rapid wear of both the eccentric shaft and the rod bearing bore, even though the loading was light. Replacement and repair were costly. An inexpensive steel-back, babbitt-lined insert bearing was substituted. The combination of babbitt on a steel shaft resulted in greatly reduced shaft wear, and, when replacements were required, the expense involved was materially decreased.

MATERIALS USED IN PRECISION-INSERT BEARINGS

Probably the most extensively used bearing metal is tin-base babbitt, and several analyses are in general use. This babbitt can be supplied in connection with either steel or bronze backs, and the metal is usually applied to the back by centrifugal casting or spinning. Five of the most popular tin-base babbitt analyses are given in Table 1.

In Table 2 is shown a rating or comparison of the various

TABLE 1 COMPOSITION OF THE FIVE TIN-BASE BABBITT METALS MOST GENERALLY USED IN BEARINGS

Alloy	Tin, per cent	Copper, per cent	Antimony, per cent
A	90	2.0	8.0
B	89	3.5	7.5
C	91	4.5	4.5
D	87.5	5.75	6.75
E	85	7.5	7.5

physical properties of these babbitts. When these alloys are used no particular attention need be paid to maintaining high shaft hardness.

For steel backs, S.A.E. Nos. 1010, 1015, and 1020 are successfully used in split bearings, the hardness being held at the minimum of Rockwell B-60. Where a full-round steel-back bearing is pressed into a steel housing member, a higher-carbon

TABLE 2 COMPARISON OF PHYSICAL PROPERTIES OF TIN-BASE BABBITT METALS

Rank	1	2	3	4
Tensile strength	*E*	*B*	*C*	*A*
Ductility	*A*	*C*	*B*	*E*
Resistance to deformation	*E*	*B*	*A* or *D*	*C*
Highest melting point	*E*	*D*	*C*	*B*
Compressive strength				
To 212 F	*E*	*B* and *D*	*A*	*C*
212 to 370 F	*E*	*A*	*B* and *D*	*C*
Hardness				
To 160 F	*E*	*D*	*B*	*A*
160 to 260 F	*E*	*B*	*D*	*A*
260 to 400 F	*E*	*D*	*B*	*A*

TABLE 3 ANALYSES OF THREE BRONZES USED FOR CAST-BRONZE BACKS FOR BEARINGS

Analysis, per cent	1	2	3
Copper	85	80	85
Tin	5	10	5
Lead	9	10	5
Zinc	1	..	5

steel such as S.A.E. No. 1035 has been found desirable to avoid "pickup" when the bearing is pressed in.

Cast-bronze backs are widely used, and several satisfactory analyses are available for this purpose. Manganese and aluminum bronzes, however, should be avoided. The three analyses given in Table 3 have been successfully used. The 80-10-10

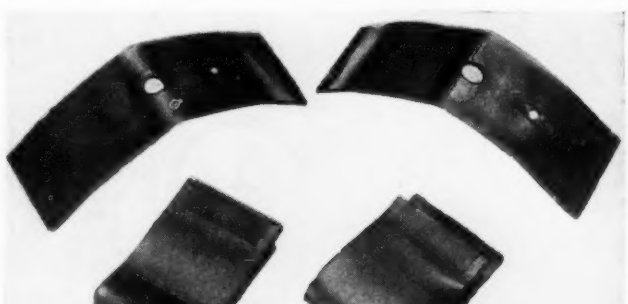


FIG. 7 RESULTS OF BEND TEST ON TIN-BASE AND CADMIUM-SILVER LININGS IN STEEL-BACK BEARINGS

(The specimens at the top have the tin-base lining and those at the bottom are lined with cadmium silver. The lining on the specimen in the upper right corner fractured, but the others remained intact.)

composition is favored in some quarters because it is inherently a good bearing material, and in cases where thrust flanges are an integral part of the bearing, the babbitting of these flanges is frequently omitted as a measure of economy.

High-lead babbitts present interesting possibilities and are being regularly supplied in bearings with both steel and bronze backs. More experience appears to be required with these babbitts, however, before their field of usefulness is fully understood. Precision-type bearings are also obtainable in phosphor and leaded bronzes of various analyses to suit different conditions of speed, load, lubrication, operating conditions, and other factors.

For special installations involving loads of from 2000 to 3000 lb per sq in. and shaft speeds ranging from 35 to 45 fps the

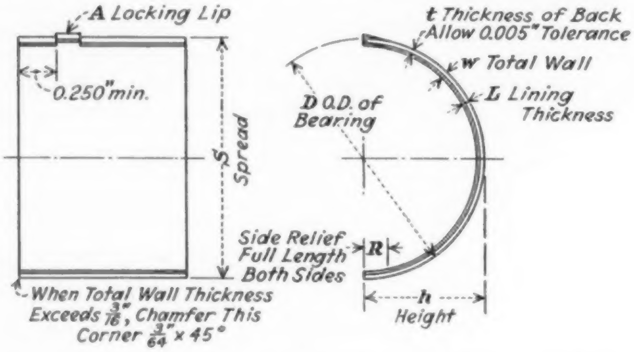


FIG. 8 ELEMENTS OF A PLAIN UNFLANGED SPLIT PRECISION-INSERT BEARING

newer so-called high-duty automotive-engine bearing materials, including cadmium silver, cadmium nickel, and the copper leads, are available. These are always supplied in combination with a steel back. Fig. 7 shows a comparison of the tensile strength and ductility between cadmium silver and a high-grade tin-base babbitt composed of tin, 89 per cent; antimony, 7.5 per cent; and copper, 3.5 per cent as evidenced by a bend test on steel-back bearings. The lining thickness on both was 0.020 in. The specimens at the top are tin-base babbitt, and the degree of bend shown is the limit, as the lining in the upper right corner has been fractured. The specimens at the bottom are cadmium silver, and the lining is free from fracture. Before these materials are specified, the bearing manufacturer should be consulted to insure that all conditions required for a satisfactory installation are satisfied. Among these conditions are shaft hardness, oil clearance, method of lubrication, oil temperature, etc.

PROPORTIONS AND DESIGN FEATURES OF PRECISION-INSERT BEARINGS

The elements of a plain unflanged split precision-insert bearing are illustrated in Fig. 8. The back may be either steel or bronze and the lining, tin-base or high-lead babbitt, cadmium silver, or cadmium nickel. Dimensions for features which are typical of this type of bearing, such as lining thickness, thickness of bearing back, total wall thickness, height of bearing, spread, locking lip, and side relief, will now be established.

Lining Thickness. Recommended values for this dimension L are given in Table 4. Lining thicknesses of less than the

TABLE 4 RECOMMENDED LINING THICKNESSES

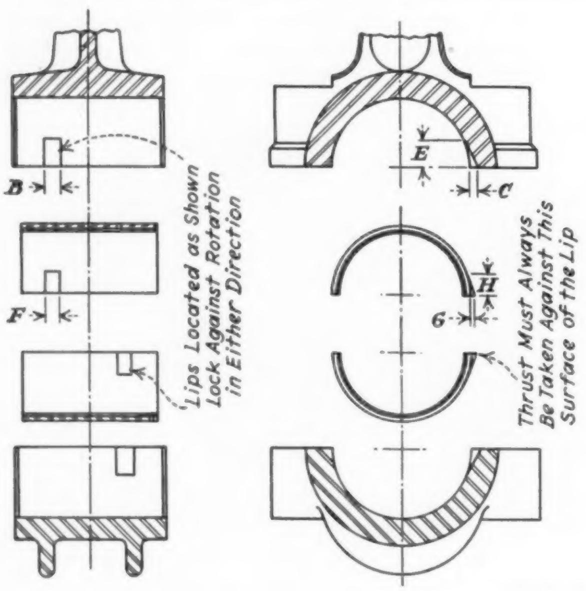
Shaft diameter, in. From	To	Lining thickness, in. Minimum	Maximum
0	$2^1/_2$	0.020	0.025
$2^9/_{16}$	$3^5/_8$	0.025	0.030
$3^{11}/_{16}$	$4^3/_{16}$	0.030	0.035
$4^1/_4$	6	0.040	0.045
$6^1/_{16}$	11	0.060	0.070

values given have been used, but the ailments to which some of these bearings have been subject leads to the conclusion that, in cases where the bond may be slightly imperfect, added bearing life can be obtained by a slightly thicker lining, since an increase in the longitudinal sectional area of the lining material

TABLE 5 MINIMUM SAFE VALUES FOR THICKNESS OF BACK

Type of bearing	Duty	t/D
Steel-back flanged	Light[a]	0.017
Steel-back flanged	Heavy[b]	0.020
Steel-back plain	Light	0.020
Steel-back plain	Heavy	0.029
Bronze-back flanged		0.034
Bronze-back plain		0.050

[a] Less than 500 lb per sq in. of projected area.
[b] Over 500 lb per sq in. of projected area.



NOM. LIP WIDTH	SLOT IN ROD WIDTH B	DEPTH C	HEIGHT E	SLOT IN BEARING WIDTH F	PROJECT. G	HEIGHT H
5/32	0.160 0.165	1/16	9/32	0.150 0.155	0.031 0.041	7/32
3/16	0.185 0.190	5/64	9/32	0.175 0.180	0.045 0.055	7/32
1/4	0.248 0.253	5/64	9/32	0.238 0.243	0.045 0.055	7/32
5/16	0.310 0.315	5/64	9/32	0.301 0.306	0.045 0.055	7/32
3/8	0.373 0.378	1/8	1/2	0.363 0.368	3/32	3/8
1/2	0.492 0.502	1/8	1/2	0.482 0.492	3/32	3/8

FIG. 9 LOCKING-LIP DIMENSIONS

will offer increased resistance to rupture or cracking due to the tensional pull of the rotating shaft.

Thickness of Bearing Back. The thickness of the back material t is very important and, in determining this, the material and stiffness of the case or housing must be considered. Back thicknesses based on the ratio t/D (minimum back thickness) ÷ (outside diameter of bearing) as given in Table 5 have proved very successful and are considered the minimum safe values. No reason other than increased cost, however, prevents using a heavier back. The important point is not to have the backs too thin.

Total Wall Thickness. In bearing sizes up to 4 in. inside diameter, the total wall thickness w can be held within a tolerance of 0.00025 in. For larger sizes, a little more tolerance is usually necessary.

Height of Bearing. The height h of each shell should be slightly greater (0.0005 in. or more, depending on size, wall thickness, housing material, and the like) than half the saddle bore so that, when two shells are assembled, the equivalent of a press fit is obtained which firmly seats the bearings and insures proper heat conductivity. The distance that this height exceeds the housing bore is termed the "crush" or "pinch," and the exact value of crush had best be determined by the bearing manufacturer.

Spread. After finish machining, the bearing is spread slightly at the parting so that some little effort is required to snap or force it into its seat. The amount of "spread" S also is best determined by the bearing manufacturer.

Locking Lip. For steel-back bearings having a steel thickness of up to 0.156 in., a convenient method of locking against rotation and locating endwise is offered by the locking lip A. This lip is stamped or formed from the back after the outside diameter is finish-ground. Standardized dimensions for lips and nesting slots are shown in Fig 9. The size of the lip can be determined as a function of the projected bearing area, and the ratio of this area to the steel-contact area of the lip should be not less than 0.0022 in.

Side Relief. To compensate for slight distortion that may be caused by the "crush," bearings are relieved at the parting. This relief is usually 0.0005 to 0.001 in. at the contact face and tapers back to zero in a height of $^1/_4$ to $^3/_8$ in., depending on the size of the bearing. In any case, the height R should be $^1/_{32}$ in. greater than the locking-lip height.

METHODS OF BEARING LOCATION AND RETENTION

For heavier-wall bearings, dowels are usually used for endwise location and locking against rotation, but, in too many cases, these dowels are incorrectly applied. For example, reamed holes for close-fitting dowels are sometimes provided in both halves of a bearing. Obviously, angular variations will occur in the location of the hole in the housing and that in the bearing, so after assembly, the conditions illustrated in an exaggerated form by the sketch at the left in Fig. 10 are likely to obtain. The contact faces of the bearings are not in the exact plane of the housing contact surfaces, and too much crush, which causes a distorted bearing wall, will exist on one side and a gap on the other.

A close-fitting dowel should be used in one shell only to locate it endwise and also prevent rotation. In the other, the hole should be elongated circumferentially, as shown in the sketch at the right of Fig. 10, so that the bearing can float to proper contact with its mate during assembly.

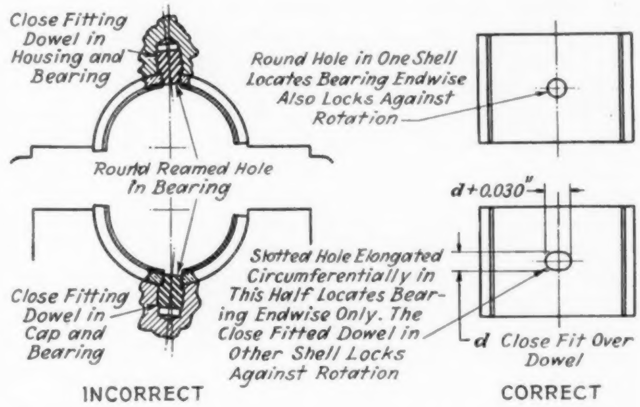


Fig. 10 CORRECT AND INCORRECT USE OF DOWELS IN BEARINGS

(Close-fitting dowels should not be used in both halves of a bearing as shown at the left; the preferred method is to elongate one of the dowel holes as in the sketch at the right.)

With flanged bearings, the situation is somewhat different, since the flanges provide for endwise location, and locking against rotation is usually necessary in one shell only. Flange clearance over the housing is necessarily close, and a close-fitting dowel, in addition, makes a rather impossible combination unless some fitting is to be resorted to.

For flanged bearings, the dowel hole should be elongated longitudinally. A close fit is obtained against rotation with extra clearance endwise.

As an alternative to stamped-out lips or dowels, bearings can be retained by keys such as are shown in Fig. 11.

These locking keys are applied in the bearing cap on one side of the bearing. Use of only one key locks both halves of the bearing against rotation and locates the lower half in an end wise direction. Endwise location of the upper half is secured by a dowel.

The precision insert (interchangeable) bearing has been of real value in the automotive field and its features should be of benefit in other types of industrial machinery.

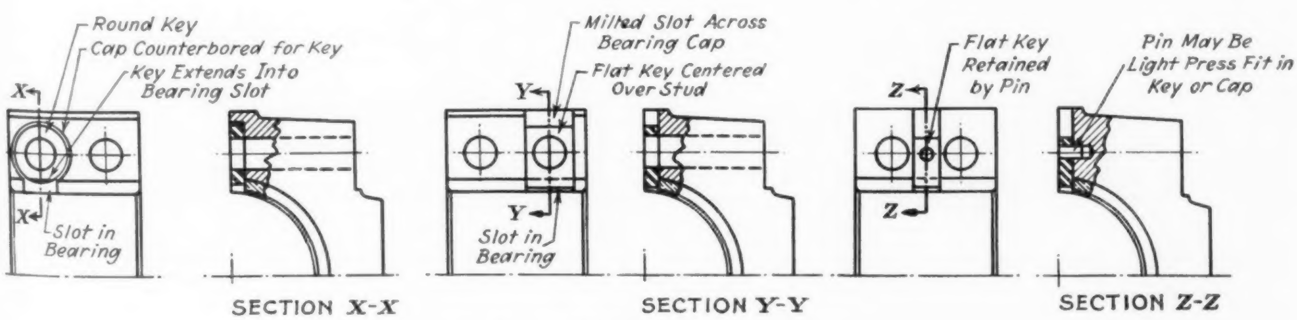


FIG. 11 TYPES OF BEARING LOCKING KEY

CONDITIONING FRUITS *and* VEGETABLES

By J. E. MITCHELL

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LACK OF progress in developing the transportation phase of the produce industry has long been recognized as the weak link in marketing methods. This situation is largely due to the great investment that the railroads have in 150,000 refrigerator cars which have been built from time to time as need arose and have not been materially changed in design or protecting qualities against heat entering the car in summer and escaping during the cold winter months. Standard refrigerator cars have a loading space of approximately 2000 cu ft between ice bunkers which are located at each end of the car or about 35 ft apart. Air circulates from the bunkers entirely by gravity, and the heat transfer is much too slow to remove the field heat from the produce and simultaneously resist the entrance of heat through the car body. Also, the circulating air must contend with the heat of respiration from the perishable load. The equipment used today to bring fruit and green vegetabes from California and Florida to New York does not differ materially from that used 20 years ago on hauls from Maryland, Virginia, and upper New York State.

Studies in recent years have, therefore, been directed toward a reduction in existing losses from mold and decay and eliminating the shipment of unripened produce with resultant low returns to the grower. Many things had to be considered, such as bacteria-carrying surface moisture and fungus spores that are carried by and breed in stagnant air containing a high percentage of humidity. These studies have shown that losses which the shipper formerly accepted as unavoidable could be prevented if a practical method were developed for conditioning the produce to withstand hauls of 1000 miles in cars with limited refrigeration capacity, which generally means delivery on the third morning after the car leaves the packing house.

Fruit and vegetables are very much alive after harvesting, and bacteria life, as well as the accumulation of injurious gases caused by respiration, can be checked only by conditioning against such developments with which the refrigeration provided in the car cannot cope satisfactorily. When peaches are loaded into a car at 80 F, the heat of respiration is 11 Btu per lb per 24 hr and 1 ton of ice per 24 hr would be required to keep the 30,000-lb load at the 80-F loading temperature. If, however, the temperature of the peaches had been lowered to 40 F immediately upon loading, the heat of respiration would be 0.9 Btu per lb, and the melting of 200 lb of ice would create sufficient refrigeration. Bacteria in the peaches increase proportionately with the rate of respiration, and the storage life of a carload would be increased 12 times if the field heat were removed before starting the fruit on its journey to the distant market. Thus, the grower can, in the future, leave the peaches on the trees before picking for several days longer than was fomerly considered possible, and the fruit will still remain in good condition at the retailers for a sufficient length of time. Shipping ripe peaches is advantageous financially to the grower, because the fruit fills out more as soon as maturity is reached than it does in a much longer time while green.

Removal of surface moisture is very important in retarding stem rot in citrus fruit. This develops only when the skin cells are clogged with surface moisture that stops the outlet for carbon dioxide and other gases which are given off by all fruit when ripening. Experiments indicated that forcing air over the ice in the bunkers and through the load was a step in the right direction but was unsatisfactory because of the small refrigeration capacity available, the time required for precooling by this method, and the high cost.

Once the surface moisture is removed, the fruit has a longer storage life than was previously considered possible. Cars, from which moisture has been removed, are forwarded without any ice in the bunkers and the ventilators are closed until the temperature of the produce in the car has risen to the average outside. This method of conditioning has been made possible by installing a complete portable plant on a truck chassis. All power required is furnished by the truck engine through takeoff gearing which receives power from the coupling shaft gearbox. Immediately in back of the driver's cab is mounted a 250-gal water tank which is the reservoir for the evaporative condenser. Back of this tank two 15-ton compressors are mounted which are driven from the power take-off shaft by eight V-belts for each compressor. The evaporative condenser and the cold diffuser, which complete the plant, are located behind the compressors and directly over the four rear wheels of the truck.

To condition a loaded car, the unit is driven opposite the side door, and a flexible duct is led in above the load. This duct has an air-spreading device that distributes 12,000 cfm of cold washed air evenly throughout the car. A second duct leaves the car at the floor level, and, through it, is drawn air that has passed through the lading and has picked up heat and whatever moisture has evaporated from the surface of the fruit into the air in the car. This air is delivered to the cold diffuser, and, in passing through it, some of this moisture condenses, the quantity depending upon the differential between exhaust and suction temperatures.

This system has also been applied successfully to rapid ripening of tomatoes by using heat and vapor from the evaporative condenser. Uniformity of size, rather than the degree of maturity, governs the picking of this product which, formerly, was placed in ripening rooms at the terminal markets where heat from a kerosene stove was applied without any regard for the proper percentage of humidity in the air. As tomatoes will decay after 4 days when exposed to a carbon-monoxide concentration of only 6 per cent at 60 F, heavy losses resulted. With the new method, approximately 7 lb of vapor is supplied to a carload for each degree that the temperature is raised to force ripening. This temperature rise is 20 deg, and the method accomplishes as much ripening in 24 hr as ordinarily occurs in a ripening room in 5 days and has eliminated repacking loss or shrinkage which formerly ranged between 20 and 30 per cent and was regarded as unavoidable by the growers.

One of the earliest applications of the method was the removal of approximately 250 lb of surface moisture from each of 400 carloads of potatoes. Other perishables with which it has been used successfully include strawberries, citrus fruits, beans, cantaloupes, and leafy vegetables. Dewberries, which were formerly considered too perishable for shipment in carload lots, are now being marketed on a large scale.

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SURFACE BROACHING *in* HIGH-PRODUCTION INDUSTRIES

Automotive Parts Manufactured Rapidly and at Low Cost per Piece

By S. EINSTEIN and M. ROMAINE

CINCINNATI MILLING MACHINE COMPANY

FIG. 1 ROTARY BROACH FOR BRAKE SPREADER CAMS

BROACHING, while popularized only in the last one or two decades, is an old art. For example, the great Leonardo da Vinci, who lived from 1452 to 1519, had numerous sketches in his notebook which disclose, in principle, broaching tools as known today. The broaching of holes has long been a common operation in most machine shops. Also, in the last twenty years in some shops, broaching on external surfaces was performed by using old broaching machines or presses. Similarly, in a few instances for broaching slots, gear teeth, or other surfaces, planing machines were used with the tool fastened to the bed and the work held on a fixture fastened to the rail. Only in the last decade have machines, especially adapted for this operation, been designed, with remarkable success, to combine economic production and a satisfactory degree of accuracy and finish.

Surface broaching is a process of machining surfaces by tools having a number of successive cutting teeth of increasing size and cutting in the same general path. Various types and sizes of surface-broaching machine are on the market today, comprising either continuous machines, in which the work or the cutting tool travel, relatively to each other, in a circular or rectangular path, or the so-called ram-type construction, in which either work or tool is stationary with relative movement between them in a straight path. In the latter case, these machines are either of the horizontal or vertical type with one or more cutting tools and workpieces. Shape, size, and quantity of production are generally the leading factors in selecting the type of machine to be used for finishing a part by the broaching method.

Advantages of surface broaching are

(1) Exceptionally high production in the machining of flat or irregular surfaces on duplicate parts.

(2) Roughing and finishing to size in one operation.

(3) Large production before resharpening.

(4) High degree of finish.

(5) Close tolerances in machining can be maintained continuously.

(6) Due to long tool life and exceptionally high production, low cost per piece on parts broached is secured.

The automotive industry offers the greatest possibilities of surface broaching. Among parts capable of being so machined are top, bottom, manifold face, water jacket, and flywheel housing of cylinder blocks; cylinder heads; crankshaft bearings; connecting rods and caps; shock-absorber arms; steering knuckles; shock-absorber bodies; transmission shifter rods; rear-axle shaft ends and many others.

Limiting factors of surface broaching are

(1) Work must be strong enough to withstand broaching stresses set up.

(2) Work must have the ability to be supported firmly.

(3) Work cannot have any obstruction in plane of surface to be broached.

Like any other manufacturing process, surface broaching requires a suitable machine, broaching tool, fixture for holding the work, and the work itself.

BROACHING BRAKE SPREADER CAMS AND REAR-AXLE SHAFT ENDS

Fig. 1 shows a rotary broaching machine for machining brake spreader cams where the cutters are mounted on a standard or column, around which rotates a ring-type table carrying holding fixtures. In this particular application, the length of broaching tool that could be accommodated on this machine was sufficient to make it in two parts; thus, two operators could be stationed on the machine 180 deg from each other, and with automatic clamping and ejection fixtures, the high hourly production of 3800 pieces was obtained.

A single-ram, receding-table, vertical broaching machine for broaching rear-axle shaft ends is illustrated in Fig. 2.

A special work-holding fixture, mounted on the receding table, is arranged to hold two shafts in V-blocks, one located directly under the cut and one at the opposite end. End loca-

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FIG. 2 FINISHING REAR-AXLE SHAFT ENDS WITH A VERTICAL SINGLE-RAM BROACHING MACHINE

tion is taken against the inside of the wheel flange. Both shafts are clamped simultaneously by a hand-operated clamp in contact with the outside of the wheel flange.

The operating cycle is to load two shafts, advance the table, broach two pieces, and return the table and the ram to the starting position. The operator removes the two pieces and loads the table with two more while the ram is returning, only a little extra time being required to complete the loading of the work at the end of each cycle.

Broach speed is 31 fpm forward and 47 fpm on the return stroke. The material is a steel forging; $^1/_4$ in. of metal is removed from each piece; and the production is 356 pieces in 52 min. The broach tools are high-speed steel.

Fig. 3 shows refrigerator cylinders being broached in a vertical duplex hydrobroaching machine. This job is especially interesting since five surfaces are broached in two settings of the work. Two special work-holding fixtures, each arranged to hold one cylinder, are mounted in position on the indexing table of the machine. That at the right-hand station is used for broaching the bottom and bolt lugs of the cylinder, while the other is for the top and one side.

The fixtures are arranged for progressive machining and are adapted for two sizes of cylinders. Work is located from the rough casting in the first operation, while location for the second operation is taken from those finished surfaces having major axes of work in the vertical plane. Air-operated clamps are a feature of both fixtures.

Parts of the work and the fixtures are completely surrounded by the broach holder during the working stroke of the first operation. Another feature is mounting the broach inserts in a 90-deg V for the second operation. The broaching tools are two rows of high-speed steel inserts in special holders. Material is cast iron, $^1/_8$ in. of stock is removed, and 185 pieces are produced in 52 min.

An extremely interesting operation where large production is obtained on pistons for a hydraulic shock absorber is illustrated in Fig. 4. These pistons are castings that have webs cast across the end of the cored-out slot to permit the part to be ground on a centerless grinding machine. The broaching operation opens the slot by removing the web and must produce a slot of rather close tolerance and good finish. Production requirements are rather high and a somewhat novel arrangement was used to obtain it. Instead of the oscillating or indexing type of table normally used on the duplex broaching machines, this machine is equipped with a table that indexes back and forth across the face of the machine. In the center of the fixture is an indexing drum having 10 stations located axially on the drum. On each of the stations, four pieces are located by pins through the cored hole in the piston, and the operator's duties are limited to putting pieces on these pins. The drum is located on a slide that moves back and forth at right angles to the face of the machine so that the pieces, which are set on the drum with their axes horizontal and have been indexed into that position, are pushed forward into holes in the work-carrying shuttles. This ejects the finished pieces between the column and the knee of the machine and collects them in the base. After the four pieces have been inserted into the shuttle, the drum is retracted. At the completion of the strokes of the two rams, one up and one down, the work shuttle moves sidewise, bringing the fresh pieces that have just been loaded in front of one ram and also bringing those that are finish-broached in front of the drum. The drum then moves forward, indexing on its way, pushes the four broached pieces out of the shuttle, and replaces them with four new ones. This action is continuous, and the drum is automatically indexed and timed with the motion of the work-holding slide. A production of 2160 pieces in 52 min is obtained with a broaching speed of 41 fpm.

CONNECTING RODS AND CAPS

Today, practically all connecting rods and caps are finished by broaching. Fig. 5 shows the machining of the half bore and parting face.

For broaching the side locating pads and bolt bosses on forged-steel connecting rods and caps, two special work-holding fixtures are mounted on the indexing table of the machine. Each of these fixtures is arranged to hold one connecting rod and one cap abreast. The cap rests on the previously broached side and is located from the rough half bore, and the connecting rod rests on the previously broached side and is located sidewise from the reamed wrist-pin hole and radially from

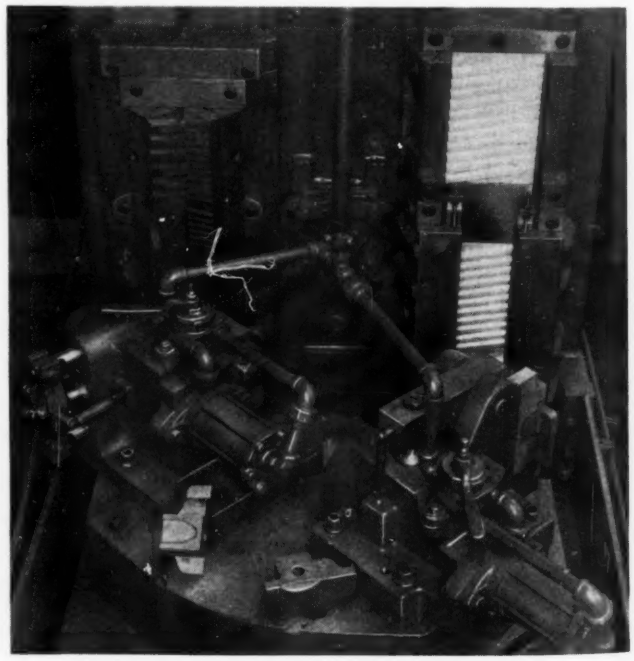


FIG. 3 FINISHING FIVE SURFACES WITH ONLY TWO SETTINGS OF THE WORK

(The part is a refrigerator cylinder, and 185 pieces are produced in 52 min on a vertical duplex broaching machine.)

the rough half bore. A single weighted cam lever clamps the rod over the top and the cap over its back, and, in operation, the clamps are straddled by the broach. Hourly production is 450 pairs with a broaching speed of 31 fpm and a stock removal of between $^1/_8$ and $^5/_{32}$ in.

A fixture for holding the rod during broaching is provided on the left side of the indexing table. Horizontal positioning is on the previously machined crank-bore face, and the rod is located longitudinally by a block that straddles the previously finished bolt bosses and axially from a stud at the wrist-pin hole. Automatic clamping is provided by a bracket and roller plunger that is spring-actuated and attached to the broach column face and a hinged clamp that bears against the I-section of the rod.

On the right side of the indexing table, a fixture is provided for holding the cap during machining. Horizontal positioning is on the previously broached boss face, and axial and longitudinal location is by two positive stops. Clamping is done by a weighted hand lever with a cam action that brings pressure to bear on each side of the bolt bosses.

FIG. 5 VERTICAL DUPLEX BROACHING MACHINE BROACHING THE HALF BORE AND PARTING FACE ON AN AUTOMOBILE-ENGINE CONNECTING ROD

On previous equipments, the parting face and the half bore were machined simultaneously, using flat broaches which interlocked with a circular broach, but the broaches shown in Fig. 5 are designed to machine the rod progressively, the half bore first and then the parting face. The tools for both portions of the operation were designed so that they took the full power of the machine, with the net result that the half-round portion was broached by a tool which was about 50 per cent as long as would have been required by the other method. In addition, the elimination of the interlock made both types of broach considerably cheaper to manufacture. The broach speed was 32 fpm; stock removal, $^1/_{16}$ in.; and the hourly production, 370 pairs.

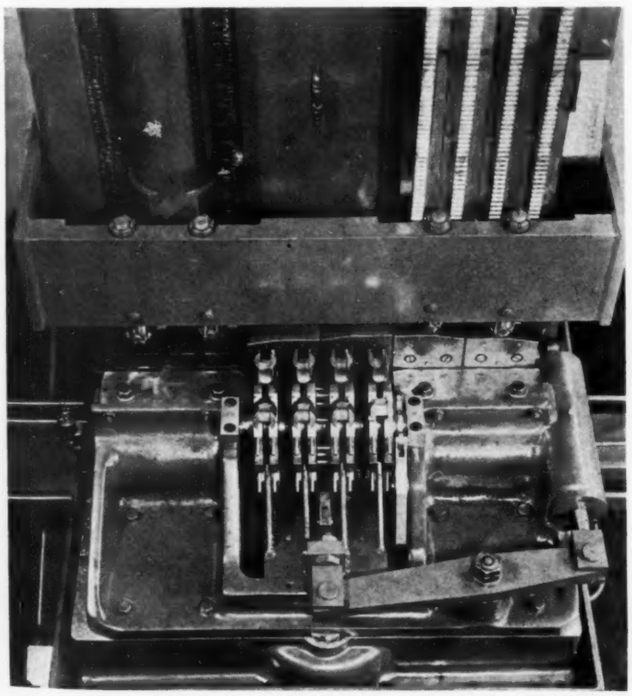


FIG. 4 SLOTTING SHOCK-ABSORBER PISTONS ON A VERTICAL BROACHING MACHINE

(A production of 2160 pistons in 52 min was made possible by a 10-station indexing mechanism.)

A special broaching machine for finishing the bearing lock and slots on cylinder blocks is illustrated in Fig. 6. This machine is of the horizontal type with a hydraulically actuated table or ram on which the broaching cutters are mounted. After being loaded into the fixture, the cylinder block is located in the path of the broaching cutters, and the cut is taken. During the operating stroke of the broach, the finished block is removed from the machine on a roller conveyor, and a new block placed in the fixture. A production of 110 cylinder blocks in 52 min. is obtained from a single machine that is served by one operator, and an accuracy of ±0.0005 in. is easily maintained. Cutters are sharpened after every 7000 pieces, and the resharpening time is approximately 3 hr. Tools are set up in the toolroom, which eliminates all cutting and trying on the machines after the setup is completed.

EXPERIMENTAL CYLINDER-BLOCK SURFACE-BROACHING MACHINE

Outstanding surface-broaching operations are performed on cylinder blocks. To secure basic data, from which recommendations for broaching equipment could be made, a large experimental machine that was powerful and large enough to broach top or bottom, end or sides of any straight-line cylinder block of any passenger-car engine then in existence was built.

Different designs of cylinder block were broached experimentally, resulting in the machine shown in Fig. 7, and, as a result, the following factors must be determined before proper machines, fixtures, and tools for this particular job could be designed:

(1) How much total pressure will the casting stand without breakage?

(2) How must the casting be supported against the broaching pressure?

(3) How must the tools be arranged so as not to exceed the strength limits of the casting?

(4) How must the tools be arranged to remove the metal in minimum time and still produce a satisfactory degree of accuracy and finish?

(5) How large a chip can be removed by each tool without

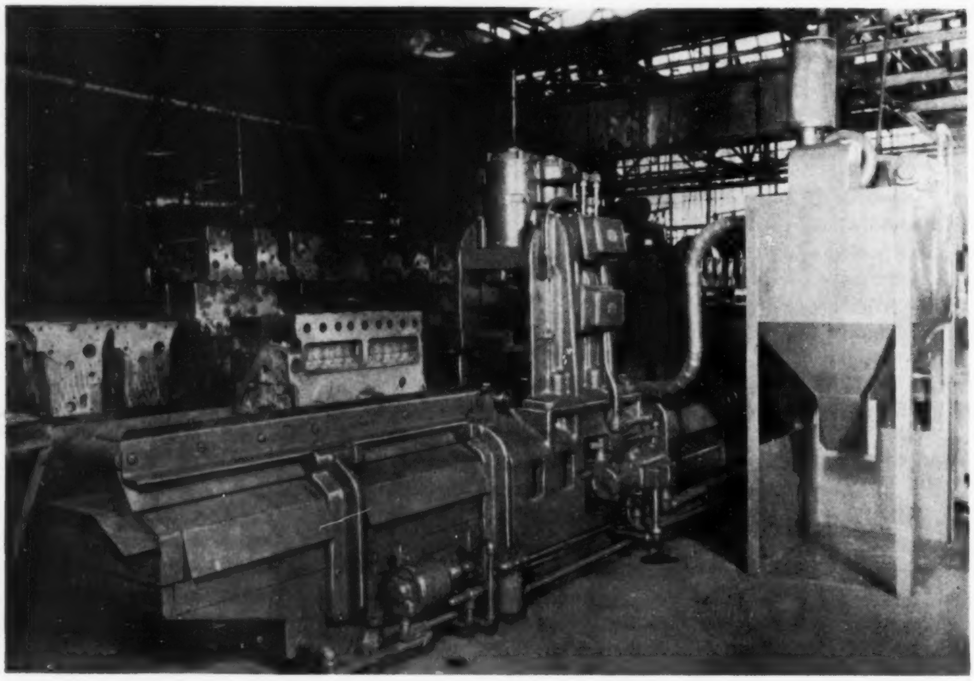


FIG. 6 BROACHING CYLINDER-BLOCK BEARING LOCKS IN A SPECIAL HORIZONTAL MACHINE

causing excessive flaking-off or breaking-back of the edge of the casting at points where the tools leave the work at the end of the cut?

The top view of Fig. 7 shows a machine for broaching the pan rail or bottom face of cylinder blocks and also the bearing-cap seats with the fixture in the down or loading position. This particular machine was designed for broaching the cylinder blocks for either six- or eight-cylinder engines by a ram that moves horizontally, the plane of the broaches being arranged vertically. Each cylinder block is slid from the conveyor into the machine fixture, where it is positioned against casting lugs and clamped. The operator then throws a lever to actuate a hydraulic mechanism that swivels the work-holding fixture upward into the position shown in the middle view, thus bringing the work into the broaching position. Upon the completion of the broaching stroke, the fixture is returned to its original position. The operator utilizes the time consumed by the return of the ram for sliding the finished block out of the fixture and loading a new one.

The equipment used for broaching the top surface of cylinder blocks is shown in the bottom view. The action of the fixtures, however, is identical with that of the one illustrated in the other two views. The production obtained from a machine is between 50 and 55 cylinder blocks per hour. Since the machines are in actual practical use, the total labor cost per cylinder block was computed at $0.039, based on a $1 hourly rate, and the tool cost per piece at $0.045. These figures indicate a considerable saving in labor and tool costs over methods previously employed.

As a result of extensive experiments, the broaching tools used are of the inserted-blade type. They have been carefully designed to remove metal to a depth of approximately $^3/_{16}$ in. in the minimum time and still produce finished pieces with unusually close tolerances for accuracy and flatness of surface and a high degree of finish. The use of tungsten-carbide finishing tools is an important factor in obtaining these results. Other operations on the cylinder block would be broaching the ends and the manifold side.

Fig. 8 shows a special horizontal machine that has been developed for broaching the joint face, bolt bosses, and water outlet on heads for a six-cylinder automobile engine. A special 90-deg indexing fixture is arranged with two work-holding fixtures, 180 deg apart, each arranged to hold two cylinder heads. This feature permits work to be loaded, removed, and interchanged while the ram is making its forward and return strokes.

Operations are progressive, the top bosses and the water-outlet face being machined first by locating from the combustion chambers on the opposite side, while the cylinder-block joint face is machined last by locating from the finished top bosses. When the ram completes a broaching stroke, the fixture is automatically indexed 90 deg, bringing one finished and one semifinished cylinder head to the top station and one fresh and one semifinished, but freshly loaded, cylinder head to the station below the trunnion. As soon as the indexing movement is complete, the operator throws the directional-control lever to return the ram and, while it is returning, he releases hydraulically operated fixture clamps on the two pieces at the top. He then pushes the finished head down the chute and the semifinished head into a trunnion transfer cradle. Immediately upon the completion of the ram's return stroke, the fixture is indexed 90 deg and the directional-control lever is thrown to start the ram on its broaching stroke. The two work-holding stations are now facing the operator in the loading position. The semifinished cylinder head is pushed in position for second operation and a fresh cylinder head is taken from the conveyor and placed in position for first operation.

Material broached is cast iron. The tool is of the inserted-blade type with 42 blades for roughing and semifinishing and one tungsten-carbide blade for finishing. Ram speeds are 31 fpm on the cutting stroke and 63 fpm on the return. From $^3/_{32}$ to $^1/_8$ in. of metal is removed, and the production is 77 pieces in 52 min. Automatic chip-disposal facilities are porvided.

SIZE AND SHAPE GOVERN DESIGN OF SURFACE-BROACHING TOOLS

Since surface broaching is a relatively new art, design of the tools is based on the experience gathered from previous installations and experiments on practical applications. Two major items, size and shape, control this design. Naturally, the former is determined by dimensions of the piece to be broached, number of teeth, their pitch, percentage of teeth for roughing and finishing, rake and clearance angles, and whether the teeth are straight, spiral, or staggered. The latter is definitely governed, to a greater or lesser degree, by the part to be broached.

Shape is a very important part of any metal-removing tool. The tooth must be designed to have sufficient strength and also to provide proper clearance and rake angles. During a

cutting operation on a planing machine or a lathe, the teeth have to remove metal and prepare a smooth finished surface. Removal of metal requires a rugged tooth form; production of a smooth finished surface requires high rake angle and a keen cutting edge. Where a single tooth has to perform both of these functions, the shape chosen must be a compromise between the form that is best for each. In a broach, the forward teeth remove the metal, and the last teeth prepare the finished surface. Thus, the front or forward teeth can be designed in a rugged manner with a relatively small rake angle to bear the brunt of the work of removing metal, while the last teeth can be designed to produce the smoothest possible surface, which would naturally require a higher rake angle than on the roughing teeth. The high rake angle and keen edge for the finishing teeth will give the minimum value for the built-up edge, thus the resulting surface will be very smooth.

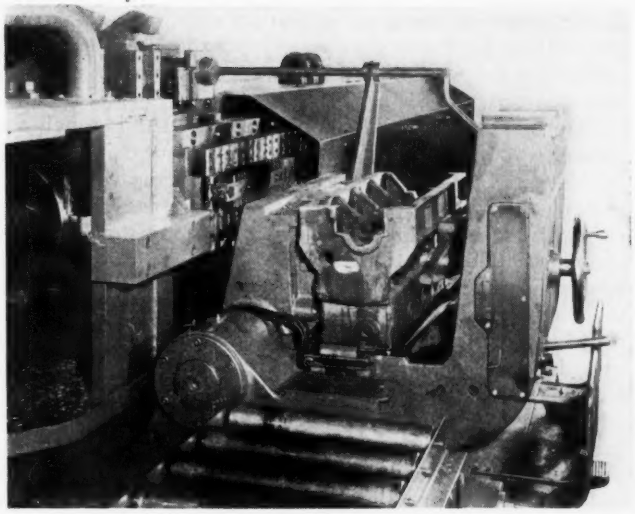
The clearance angle on tools for broaching cast iron can vary from 2 to 5 deg and have very little influence upon the force required to take any reasonable depth of cut. As in any other cutting tool, the factors governing the clearance angle on broaching tools are: First, the clearance must be great enough to prevent the tool from dragging on the work. When this occurs the finish is marred, excess heat is generated, and tool life is decreased; hence, greater force will be required for the cut and the tools dull quickly. Second, a larger clearance angle than is necessary is undesirable from the standpoint of economic tool life. Tools on the cylinder-block jobs have a clearance angle of 2 deg and give satisfactory results. Clearance angles on tools for broaching various steels are somewhat similar to those for cast iron. Clearance angles of 2 or 3 deg have been employed to good advantage on forgings of SAE 1035 and 1040 steels. For nickel-chromium steel, similar to SAE 3115, a clearance angle of 5 deg was found best, since this metal has a tendency to tear and fuse on the tool, thus spoiling the finish.

The undercut or rake angle can vary from 0 to 30 deg on cast iron and affects the cutting force and the finish obtained. Experiments on planing machines have shown that the cutting-tool force varies almost directly with the rake angle. Broaching experiments show that a rake angle of between 12 and 15 deg produces very satisfactory results on cast iron with good finishes and comparatively long tool life. Practically the same results are obtained when broaching steels or malleable iron. For steel forgings, rake angles of 15 deg are used. For stainless steels, rake angles between 20 and 25 deg will improve the finish, but tool life naturally is less than when an angle of 15 deg is used.

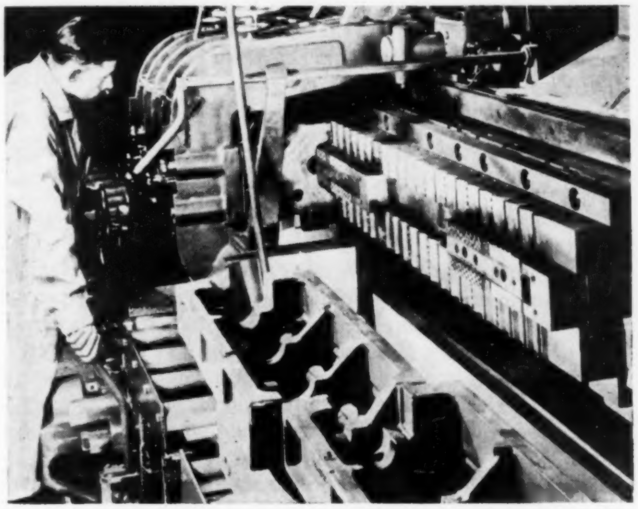
Side rake or shear angles improve the finish of a cut, whether used on planing machine, lathe, or broaching tools. For cast iron, side-rake angles of 20 deg are recommended. For steels, this angle can vary up to 30 deg. When broaching of connecting rods and caps, 0-deg side-rake angles are employed, while the angle on steam-turbine buckets was 30 deg. Side-rake angles between 10 and 15 deg are desirable on steel forgings, as they produce a fine finish and give satisfactory tool-life.

FACTORS CONTROLLING CHIP CLEARANCE

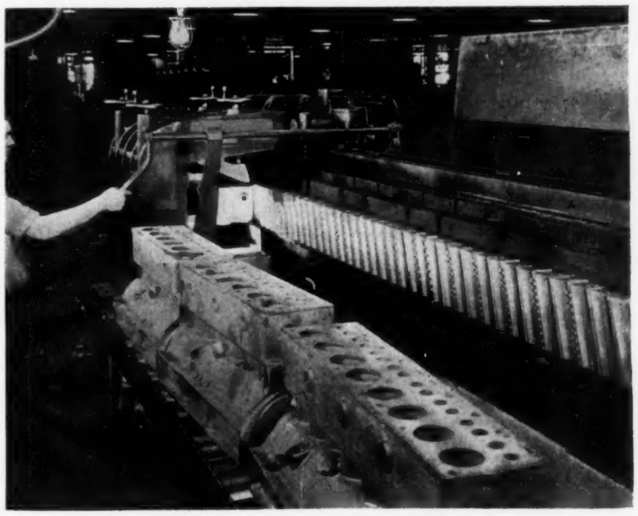
Chip clearance on a broaching tool is governed by three factors. First, the chip per tooth that any particular broach will have, as obviously, a heavy chip per tooth will require a larger chip space than a smaller one. Second, whether the material being broached has a tendency to tear or whether it has an even chip flow. Third, the nature of the chip itself; that is, if the chip tends to curl or remain straight or if it breaks or curls in one piece. Experience has indicated that a radius



(Special fixture in loading position.)



(Machining pan rail and bearing-cap seats.)



(Broaching the top surface.)

FIG. 7 HORIZONTAL BROACHING MACHINE FINISHING CYLINDER BLOCKS

in the bottom of the tooth is best for aiding the chip to curl particularly for broaching steel. It also improves the finish and lessens the possibility of cracks due to strains set up in the heat-treatment.

Chip breakers are desirable on material that is tough and forms long chips and particularly when a heavy chip per tooth is formed. Their chief function is breaking up the chips to prevent clogging of the chip-clearance space and piling-up of chips on the following teeth. Chip breakers should not be used in the finish section of a broach or on those teeth immediately preceding it, since they tend to produce grooves, which the finish teeth do not remove. Generally speaking, they are not necessary on broaches for cast iron except on heavy roughing cuts, and their function here is more to lessen the load on the individual teeth.

Chip size per tooth on a broach varies with the stages of metal removing, roughing, semifinishing, and finishing. In the roughing section, the chip should preferably be short and thick rather than long and thin, thus minimizing breakout at the end of the cut. This kind of chip also can be handled easier by automatic chip-removal devices. The finish section of a broach naturally has to remove the rough marks and lines, produce a smooth surface, and, at the same time, give the piece its proper size. On steels, a chip per tooth ranging from 0.005 to 0.010 in. can be used in the roughing section, to 0.005 in. in the semifinishing and from 0.0005 to 0.002 in. in the finishing section.

WORK-HOLDING FIXTURES

Forces set up by broaching are in two definite directions, one in line with, and the other normal to, the path of the broach, and these sometimes vary considerably in magnitude but never in direction. Holding and clamping of the piece is, therefore, greatly simplified. Knowing where the forces lie and supporting the work adequately against these forces are important. The most important point to be watched in broaching-fixture design is stabilization of the workpiece in the fixture to avoid vibration and springing while the cut is being taken.

Since cutting time on a broaching operation is relatively short, fixtures for holding and clamping the work should be quick-acting. Cam or weighted clamps are frequently used, and, in other cases, electric, hydraulic, or pneumatic power clamps are advantageously employed. In all cases, due to the large number of pieces to be handled per unit time, fixtures must be designed to reduce human labor for chucking and unchucking the work to the absolute minimum.

LOW UNIT TIME AND TOOL COSTS FEATURE SURFACE BROACHING

Low unit-time of surface broaching is due, in part, to the speed at which the cutter passes over the work, which is from 12 to 25 times faster than the rate in milling. Feed rates in milling steel forgings are seldom in excess of 8 or 10 in. and, in most milling operations on these materials, a lower rate is used. On the other hand, the normal speed for surface broaching a forging is approximately 30 fpm. In either milling or broaching, distance traveled is equal to length of cut plus distance across the cutter, and the latter is considerably greater for a broach than for a milling cutter. Higher speeds more than compensate for the difference, with the result that the cutting time by broaching is usually much faster than for milling.

The second important advantage of the broaching method lies in the low tool cost per finished piece usually obtained. In comparison with milling, first cost of broaching tools is rather high, and where face milling cutters are used, the difference in the original cost of cutting tools is rather obvious. Where complicated milling-cutter gangs are used, it is not so obvious, but, even there, the first cost of a milling cutter is less than that of a broach. Milling cutters on the arbor may be compared with broach inserts, and, generally speaking, the cost of these inserts is higher than that of milling cutters. The cutter arbor and the spacing collars for the milling-cutter gang, which support and properly locate the cutting tools the same as the subplates and holders do in the broaching setup, cost considerably less. As a result, the first cost of tooling is generally greater on a broaching than it is on a milling machine.

However, when comparing the total actual cost of the tools used in high production, the broaching tools show a lower total cost. This is due to the extremely long life between grindings, which is usually days with broaching cutters, as compared to hours for the milling cutters.

Long cutter life resulting in low tool cost is due to a number of factors, among which rigidity of the average setup and low cutting speed may be mentioned. Milling cutters normally run at between 70 and 80 or more feet per minute, while broaching tools pass through the work at approximately 30 fpm. One of the chief factors favoring the broach is the fact that a tooth takes a chip of constant thickness; it does not have to build up that chip from zero to the maximum thickness as the ordinary milling cutter does. Resultant movement of the cutter tooth relative to the work means that the milling cutter has to be sharpened with a fairly high clearance angle and has to be backed off to maintain a rather small land, with the result that heat conduction from the milling cutter is not as satisfactory as might be desired.

On the other hand, the broaching tool separates a chip of definite thickness and constant section from the work the moment the tooth starts into the work. The broaching tool is not being forced into the work but splits off a chip ahead of it, with the result that it can be operated with a much smaller clearance angle than the ordinary milling cutter. No necessity exists for any backing or back-off angle or of a narrow land, as in the case of the milling cutter, so that the heat conduction is better. In broaching, abrasion due to rubbing-over the work before starting a chip is eliminated, and lower clearance angles can be employed, resulting in a stronger tooth and less inherent wear of the tool.

Easier application of coolant is an important factor in broaching. A milling cutter revolving at between 60 and 75 or more feet per minute throws the cutter coolant, by a centrifugal action, away from the point where it is most needed. On a broaching tool, coolant can be directed exactly where it is wanted and actually flows between the tooth spaces under a slight pressure, acting, therefore, to separate the chip from the tool and giving more satisfactory lubrication and cooling.

Broaching tools have a long life because the roughing teeth remove the metal and the finishing teeth do the finishing. The former can stand considerable punishment, while the latter do not encounter any scale, remove only the minimum of stock, and, thus, should last much longer before resharpening is necessary.

DEPTH OF STOCK REMOVED IS IMPORTANT

When all the advantages of a broaching method are considered, the surprising thing is that surface broaching has not been more generally used and is largely confined to high-production and the automotive industries. Stock removal varies from a few thousandths to a total of about $^1/_4$ in. as the maximum. In looking through various published data, a stock removal of more than $^1/_4$ in. is never mentioned. In almost every

case where surface broaching has been applied, the stock is removed from a forging or from a surface previously machined, or from castings that were made in mechanical foundries by high-production methods where much variation in dimensions is not permitted. In other words, the method has been used on parts where the stock removal is not only comparatively small, $^1/_4$ in. or less and usually about $^1/_8$ in., but also is held within fairly close limits. Only in high-production industries do rough parts come through with an average stock-removal of $^1/_8$ in. or less. Other industries cannot afford to spend the money on pattern and foundry equipment required to hold castings to certain close limits, nor can they spend the money on forging dies and their upkeep which is necessary to keep down the stock to be removed.

Stock removal has an important influence on broaching because, as stated previously, the length of cutter travel past the work in either a milling or a broaching machine is equal to the length of the work plus the distance across the tool. With a milling machine, this distance is constant, regardless of how much stock is to be removed, or practically so. If excess stock is encountered, the milling-machine operator can, by decreasing the rate of feed, manage to complete the cut with little difficulty. As a matter of fact, doing anything more than decreasing the rate of feed to take care of excess stock is practically never necessary. On a broaching machine, however, if a piece that normally requires a broach 30 in. long and has $^1/_8$ in. of excess stock comes through with a total of approximately $^1/_4$ in. of stock to be removed, doubling the broach length is necessary, which doubles the length of travel and time required to produce the piece. In other words, the broaching tool is designed to remove a certain depth of stock which requires a certain force. The speed at which that force is applied is a matter of power but does not affect the rigidity of the machine or the length of the stroke. Slowing down the speed does not remove excess material. Of course, two cuts could be taken if the equipment were designed so that the first $^1/_8$ in. could be removed at one stroke and then an adjustment made to remove the second $^1/_8$ in., which is perfectly feasible but is not usually done on high-production setups such as those that have been described. Without prior inspection of the work to determine that the stock is within the limits for which the tool is designed, the result is that when a piece with excess stock is put into the fixture on a broaching machine, the first tooth of the broach tries to remove all the excess stock which is manifestly impossible and usually results in breaking and ruining a portion of, or the entire, broaching tool. The only way to play safe is to design the broaching tools for the maximum depth of stock that will ever be encountered. This means, of course, that the time per piece will be the same for pieces having less excess stock as it is for those with the maximum stock. From the foregoing, any increase in the use of surface-broaching machines would appear to depend more or less upon the development of forging and foundry practice to a point where variation in the depth of stock to be removed can be held within close limits and to the minimum.

The rather high cost of tool equipment militates against broaching, especially in the low-production industries. Broach holders, subplates, and inserts cost considerably more than arbor gangs, and the amortization of these extra costs over the expected quantity of pieces to be produced usually makes broaching a limited number of pieces, when analyzed to include this factor, considerably more costly than milling, although the actual labor cost for broaching is much lower.

Another point to be considered is that, even in high production, many pieces have a shape which precludes using the broach. To broach a surface on any part, this surface must be located on the work so that a broach of considerable length can be passed over it. Sometimes, meeting this condition is not possible, which eliminates the broach.

In conclusion, broaching has been and is being successfully applied to many high-production operations. To a large extent, it is replacing other machining methods, and this will continue. However, the determination whether a given operation should be performed by broaching or milling or by other methods can only be made after a careful analysis of all possible methods, taking all the factors into consideration, both from the standpoint of mechanics and the economics involved. This analysis, of course, requires a rather complete study of the possibilities and of the equipment and machinery available to get the maximum results by either method.

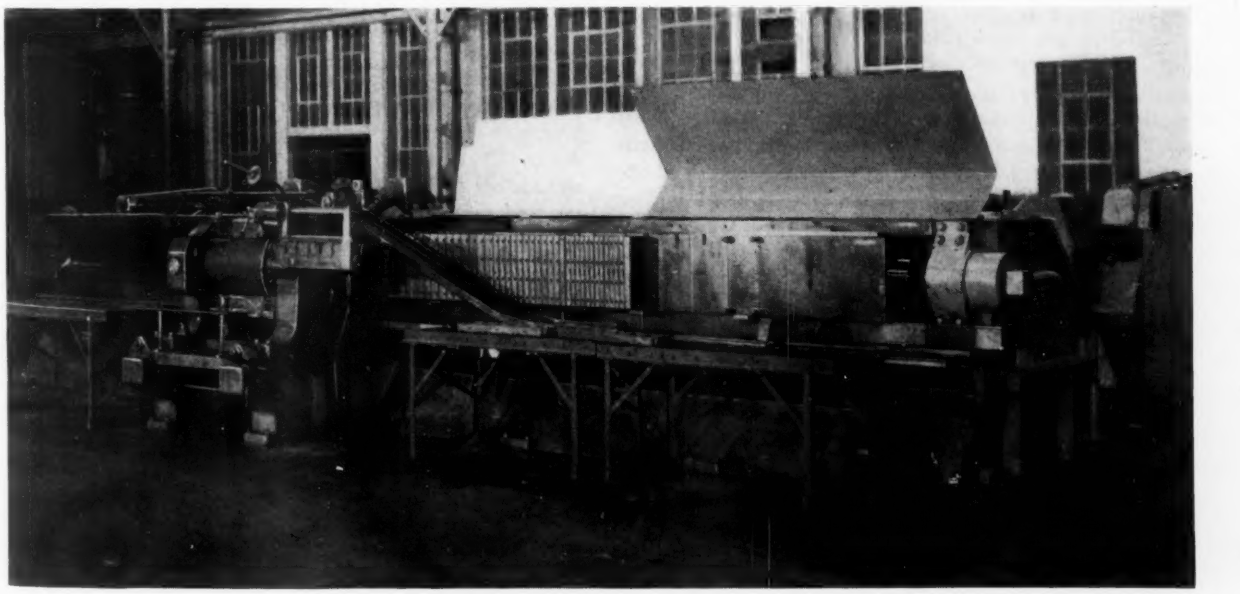


FIG. 8 SPECIAL HORIZONTAL MACHINE FOR THE CYLINDER HEADS OF SIX-CYLINDER AUTOMOBILE ENGINES

(The work-holding fixtures, each arranged to hold two cylinder heads, permit the top bosses and water-outlet face to be machined on one piece and the cylinder-block joint face to be machined on another, work being loaded, removed, and interchanged without stopping the machine.)

Reducing Radiation Errors in

GAS-TEMPERATURE MEASUREMENT

By W. L. SEVERINGHAUS

DEPARTMENT OF PHYSICS, COLUMBIA UNIVERSITY, NEW YORK, N. Y.

THE difficulty of measuring the temperature of a flowing gas accurately is well known to all workers in that field. Putting a thermocouple in a Bunsen flame gives the temperature of the thermocouple but not that of the flame. The conduction of heat along the couple keeps the junction temperature far below the flame temperature. In addition to this, heat is lost from the couple due to radiation to the region outside the flame. Many years ago, Nichols and Merritt at Cornell University attempted to approximate the true temperature by using a series of thermocouples of diminishing diameter and extrapolating the curve to the point of zero diameter. This method would seem to take care of conduction very well, but it does not eliminate heat loss by radiation which increases as the fourth power of the absolute temperature in the case of a black-body radiator.

In measuring a flue-gas temperature, the walls are generally colder than the gas, and the gas and thermocouple are continuously losing heat to the walls by radiation and conduction. To surround the couple with a protecting tube having the couple junction head upstream with some length of the couple wires in the gas stream tends to reduce the errors arising from conduction and radiation. However, the outside of the shield is continuously radiating to the flue walls which permits the gas in the tube as well as the thermocouple to lose heat to the tube by radiation.

To remedy this loss from the thermocouple by radiation Prof. C. E. Lucke has proposed using two coaxial tubes of different diameter instead of using one tube and one thermocouple. One couple is placed in the inner tube and the other in the annular space between the tubes. An auxiliary heating coil is wound on the outer tube and the wattage adjusted to the point where the two couples indicate the same temperature. If the two spaces are at the same temperature, the net exchange between the center space and the annular space laterally must vanish. Radiation losses from couples through the ends of the tubes may still occur, but, if the couple junctions are well immersed in the tubes, the solid angle of radiation is small.

One of the experimental difficulties is the time lag between the moment when the wattage is applied and when the couples come to equilibrium. If the temperature of the gas stream varied rapidly, the device would not respond with equal speed. The thickness of the walls of the cylindrical tubes could be reduced to some value consistent with the required strength. The thermocouple wires should be reduced in diameter as far as is consistent with strength and life. With an aspirator, the mass of gas flowing through the tubes per unit time can be adjusted. Baffle plates can be applied to cut off radiation from hot surfaces in the line of the tube axis. Many of these details have been adequately discussed by Dr. H. F. Mullikin in *Power*.[1] However, the cap surrounding the hot junction of the thermocouple must be radiating to the outside world and, therefore, maintaining a temperature gradient between the junction of the couple itself and its surroundings.

The experimental test in our pyrometry laboratory made use of a gas-air blast furnace to produce the heat. The walls of this furnace were thick and the outside temperature far below the inside. The furnace was, however, equipped with a galvanized-iron flue to carry the heat away. This was large

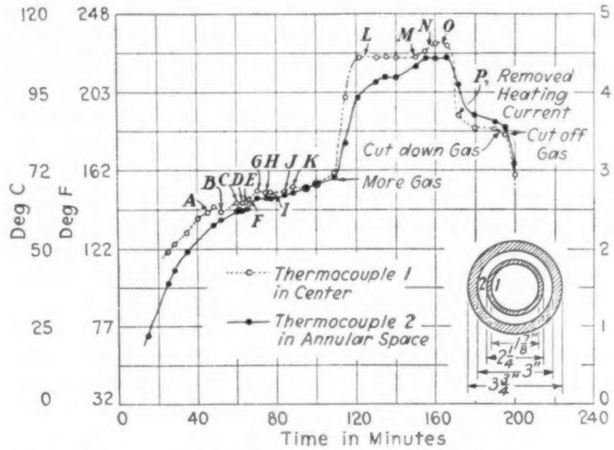


FIG. 1 RESULTS OBTAINED WITH A NEW DEVICE FOR REDUCING THE ERRORS DUE TO RADIATION IN MEASURING GAS TEMPERATURES

enough to cover the furnace at the bottom and then tapered down to about 8 in. square before entering the conduit in the building walls.

The thermocouples were calibrated against a platinum-rhodium thermocouple which had been calibrated by freezing points of chemically pure substances and the boiling point of water. The couples were made of No. 21 B. & S. gage chromel and alumel thermocouple wires. The base-metal couples were inserted with the platinum-rhodium couple into a 2-ft long electrically wound tubular furnace which was brought to temperature equilibrium at a number of points. All measurements were made on a Leeds & Northrup type K precision potentiometer. The cold junctions were kept in ice. The two base-metal couples were found to read alike at all points within the desired precision. The maximum variation was 2 parts in 160 or 1.25 per cent, and this was at a temperature approximately 200 C above the highest used in the experiment.

The two alundum coaxial tubes were each 18 in. long. One had an outside diameter of $3^3/_4$ in. and an internal diameter of 3 in., and the corresponding dimensions for the other were $2^1/_4$ in. and $1^7/_8$ in. respectively. The cross-sectional area of the annular space was 3.09 sq in. and the area at the center was 2.76 sq in. The thermocouples were introduced into the annular and central spaces to a depth of 13 in. One wire of each couple was drawn through a small-diameter porcelain tube

(*Continued on page 358*)

[1] "Accurate Measurement of High Gas Temperatures," by H. F. Mullikin, *Power*, vol. 78, 1934, p. 565.

Contributed by the Heat Transfer Committee and presented at the Annual Meeting, Nov. 30 to Dec. 4, 1936, New York, N. Y., of The American Society of Mechanical Engineers.

POOLING POWER *in a* LARGE INDUSTRIAL CENTER

By J. W. PARKER and R. E. GREENE

THE DETROIT EDISON COMPANY

WHILE THE subject of power is only accessory to the topic upon which the chief emphasis of this Semi-Annual Meeting of the Society is placed; that is, the influence in other fields of the engineering methods practiced in the automotive industry, these very practices are reflected in the demands imposed upon the central-station power system serving the Detroit area. Requiring the rapid development of an increased power supply at certain times and curtailing output and, consequently, the demand for power, even more rapidly at others, is characteristic of the automotive industry. It makes seemingly lavish use of electricity, yet the application of power to individual tools and processes has been made with continually improved efficiency. While the electricity consumed in the production of any individual part is generally less than formerly, the number of parts has increased astonishingly. The 1936 model of one of the lighter cars is reported to contain about 14,000 parts; in 1926, it contained 3000 parts. One tendency serves to counteract the other, but the modern automobile does, in fact, require an appreciably increased quantity of electrical energy in its production, compared with the car built 10 years ago.

Continuing growth of automobile production has been the major cause of the corresponding growth in the use of industrial power at Detroit, as is vividly illustrated by the curves of Fig. 1. This principal manufacturing activity has imparted its own characteristic of growth to the electrical system. As overproduction and storage of finished cars proved to be dangerous practice, production of automobiles now follows closely the changing demands of purchasers. These vary not only seasonally, but they also fluctuate rather widely with the years, and so does the industrial-power curve of the electrical system.

The rate at which electricity is used changes from hour to hour and from year to year according to the purpose to which it is put. Power is a rate of supply, a transient phenomenon amounting to a service rather than the furnishing of a commodity, in comparison with which the procurement and distribution of the most perishable of foodstuffs is a stabilized process. Even when all diverse uses of power are combined in a single system, the resulting energy flow is a widely varying thing like some mountain stream without storage reservoirs to regulate its flow.

ENERGY SALES TREBLE WHILE LOAD INCREASES 90 PER CENT

Diversity in time of use constitutes the major advantage in pooling the power requirements of any community. On that principle hangs all justification and profit. Residence and commercial users join in producing a peak load in the early evening hours, while the factory peaks occur in the morning. If, in 1936, all wholesale users of power, the manufacturers, street railways, and railroads, had each operated its own isolated power plant, they would have required equipment capable of producing the sum of their noncoincident peak loads or 490,000 kw. In the same period, the great group of moderate and small users, the householders, the retail stores, and small manufacturing establishments, imposed a peak load on the central-station busses of 354,000 kw. The system peak actually developed in supplying both of these classes was 671,000 kw. Industrial users thus increased what would have been a maximum load of 354,000 kw by 317,000 kw, although the sum of their individual demands was 490,000 kw. These wholesale users consumed, in that year, 1,642,800,000 kwhr, or 63 per cent of the entire quantity of energy sold on the system. While they increased the load that the plants had to carry by 90 per cent, they almost trebled the quantity of energy sold.

Obviously, at certain times of the year and of the day, increased quantities of energy could be supplied without, in the slightest, affecting the investment in plants and distri-

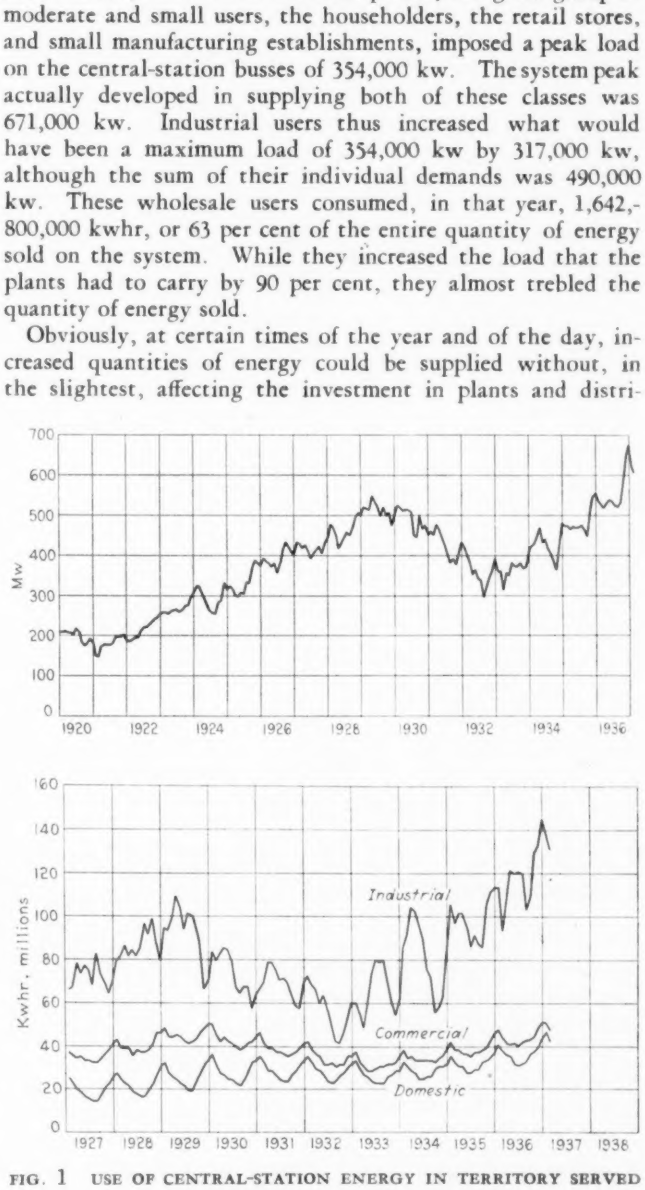


FIG. 1 USE OF CENTRAL-STATION ENERGY IN TERRITORY SERVED BY THE DETROIT EDISON COMPANY

(The lower group of curves shows the energy used by the three consumer classes since 1927. The single curve on the upper chart indicates the growth in the load since 1920 based on monthly maxima.)

Contributed by the Power Division for presentation at the Semi-Annual Meeting, Detroit, Mich., May 17-21, 1937, of The American Society of Mechanical Engineers.

bution. Wise power merchants, however, decline to sell for the bare increment cost of energy production, holding to the principle that every sale of service should carry its fair share of investment costs and so contribute to the lessening of the cost to all other users. Besides, the valley hours of today may become the peak hours of the years to come.

RESERVE CAPACITY TO PROVIDE FOR OUTAGES IS MUCH LESS

Economy of pooling facilities holds not only for equipment actually in use but also for machinery held in reserve against breakdown. Any source of power, be it small isolated plant or central station, must have spare generating units to provide for failures and to permit maintenance work. A single spare unit in a small plant may be a relatively large part of the plant capacity; or alternatively, the provision for stand-by may be niggardly, and the reliability of the service measurably below standard. Good practice in central-station management is to strive for a high degree of service continuity. Spare machines necessary to provide for maintenance and for emergency shutdown are determined from experience and judgment. Their number should increase with the number of units on the system. At present, May, 1937, 22 major steam-driven generating units are in commission in the four principal plants of the Detroit Edison system. These constitute 98 per cent of the total, approximately 11,000 kw being in hydroelectric plants on the Huron River and in small scattered units in the northern part of the district served. In addition, the system has a 30,000-kw transmission tie with the Consumers Power Company which serves the central part of Michigan and several interconnections with industrial plants in Detroit.

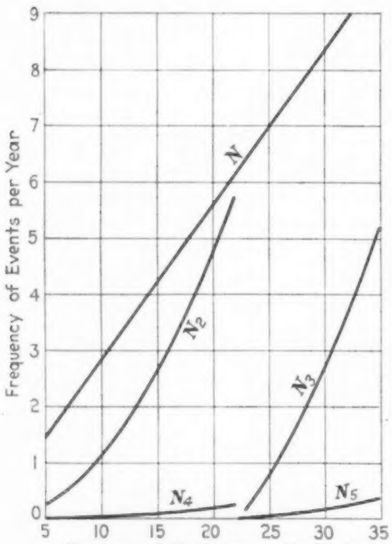


FIG. 2 PROBABILITY OF STEAM-DRIVEN GENERATORS BEING OUT OF SERVICE

The various curves refer to the following:
N —Emergency shutdowns per year
N_2—Emergency shutdowns coinciding with one maintenance shutdown per year
N_3—Coincidence of one emergency shutdown with two concurrent maintenance shutdowns per year
N_4—Coincidence of two concurrent emergency shutdowns with one maintenance shutdown per year
N_5—Coincidence of two concurrent emergency shutdowns with two concurrent maintenance shutdowns per year.

These 22 steam-driven generators are given a general maintenance overhaul once in 3 years, the average time required for each being 7 weeks. If all overhauls required this length of time, one machine would have to be out of commission continuously for this purpose only. The system has already nearly reached that condition. Furthermore, statistics covering many machine-years of operation show that, on the average, each generator is subject to an emergency shutdown once every 3.6 years due to failures within itself or its allied equipment. From these data, the probability curves of Fig. 2 have been developed, which plot the frequency of coincident generator outages that may occur against the number of generators on the system. This chart provides experience data, one of the factors necessary in the determination of spare capacity. These generator outages may, and generally do, happen suddenly. Reserve capacity in machines actually running and on the line, at least equal to the load of the largest running machine, is provided at all times against such occurrences. Moreover, a running reserve, greater than the minimum just defined, is frequently carried, but this is generally at periods of rapidly fluctuating load or whenever unusual uncertainty exists as to the immediate load that may develop. In case a machine must be shut down in an emergency, the running reserve should be restored at once, and, therefore, a second large machine is kept standing ready for an immediate start.

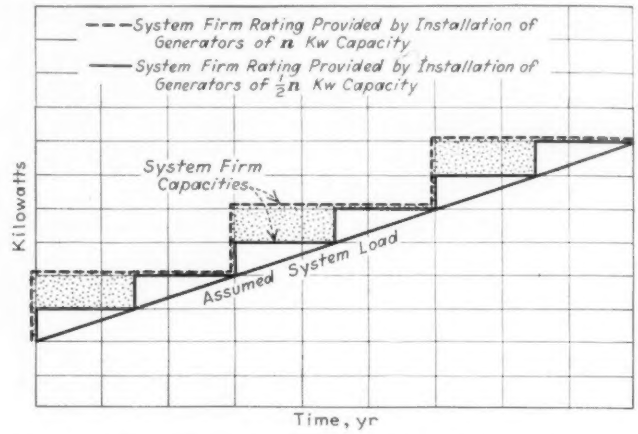


FIG. 3 UNUSED CAPACITY RESULTING FROM CHOICE OF TWO DIFFERENT SIZES OF GENERATOR

With these necessities in mind, present Detroit practice, at all times of the year, is to provide a reserve equivalent to the capacity of three major machines. This reserve is arbitrarily set, under existing conditions on the system, at 140,000 kw, which is just over 16 per cent of the total name-plate rating of all steam-driven generators. That this is a conservative reserve is illustrated by curve $N4$ of Fig. 2 which gives the expectancy of three machines being out of service simultaneously. The load can be carried with three generators crippled, and, as the probability is still smaller that such an event will occur at periods of peak loads, it is safe practice to assume that sufficient generating capacity to meet load demands will always be available.

SELECTING UNITS OF MOST SUITABLE SIZE A PROBLEM

Selection of the most suitable size of main generating units involves a difficult decision. Generally speaking, central electricity systems make effective use of larger units than would be possible for most private users. Indeed, a continual temptation is present to install larger and larger machines, as the art of turbine and generator building develops, for costs per unit of plant decrease and efficiencies tend to increase with growth in size. However, whether or not the capacity tied up in a single unit constitutes too large a part of the system total must be considered. The newest machine put into operation is just as likely to trip out as any of the remaining machines on the system, and indeed more so. If the implications of the working rule, mentioned earlier in this paper, are followed that running reserve must be instantly available to replace whatever load is being carried on the largest machine, that a second machine must be in readiness to take the place of this machine, and that such running and standing reserve must be in addition to any provision for repair outage,

the fact is readily apparent that, if a few disproportionately large machines are installed in an existing plant, they add little more to the general system reliability than would machines of more nearly average capacity. The argument verges on casuistry, but most operators would prefer to add new capacity in several moderate-sized units rather than one or two sprawling mammoths.

Another point to be considered is that, since generating capacity must, in any case, be added in units of considerable size, the dependable or "firm" capacity of the system will always exceed the load actually carried. Even theoretically, the actual load will approach the firm rating only for a short time just before a new unit is put into commission to forestall a threatened shortage. Fig. 3 is presented to illustrate the ideal case. Actually, every effort is made to maintain an additional margin of safety, since predicting what loads such a community as Detroit will build up, even six months in advance, is impossible.

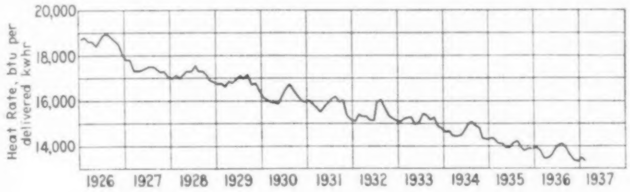


FIG. 4 DECREASE IN COMBINED POWER-PLANT HEAT RATE AT DETROIT SINCE 1926

When a new generator is put on the line, an equivalent capacity in older machines is shut down pending load growth and the larger the new machine is, the greater the integrated burden of unused investment. This also is illustrated by the diagrams in Fig. 3, in which the effects of adding new capacity, in large and in half-size increments, are compared. Choice of size is obviously affected by the rate of system growth as well as by the relationship between the capacity of the single unit and that of the whole system.

Consideration of these various factors has resulted in The Detroit Edison Company's preference for moderate-sized machines. From 1924 to 1933, the units purchased were standardized at 50,000 kw and 1200 rpm. A spare shaft with wheels assembled was purchased in 1927 and has actually been running in some one of this series of 10 machines for about 50 per cent of the time since. Only recently has the standard been changed with the installation of new 60,000-kw 1800-rpm turbines at Conners Creek and the purchase of a 75,000-kw machine for Delray.

Much specialized study is given the plants of a centralized system. Operating companies have built up staffs of men possessing knowledge obtained through long experience, who give great attention to refinements of electrical production and distribution. In some cases, as at Detroit, the operating staffs are further developed and supplemented to carry on the engineering design of new plant and system additions. This effects a coordination of engineering thinking which makes both distributing system and generating plants reflect the day-to-day experience of those responsible for their maintenance and operation.

Continuing growth of the community necessitates frequent additions to plant and system facilities. New generating equipment, invariably more efficient than the oldest units of the system, can be, and is preferentially, loaded to take advantage of the improved economy. Outdated machines are made to carry load for less and less of the time and to serve as stand-by as they approach the end of their usefulness.

Attention is called to the steadily falling curve of heat consumption per kilowatthour delivered by the four major generating plants in the 10-yr period ended with 1936 (see Fig. 4). An advantage directly attributable to a pooled-power system is that the community, as a whole, has benefited by the fuel savings made possible by the continued addition of modern generating equipment and the uniform spreading of the heavy investment burden of obsolescence.

Value of equipment, finally retired from service and eventually removed, reaches surprising proportions as evidenced by the Detroit experience. Property thus taken out of service in the 10-yr period ended December, 1936, amounted to $7,200,000 for the Delray plants and $4,410,000 for Conners Creek. Even the comparatively new plants at Trenton Channel and Marysville, though never radically rebuilt, have nevertheless been modernized continually, the value of equipment replaced being $1,045,000 and $500,000 for these stations, respectively. The total property write-off in 10 years has been $13,155,000 for these four plants.

COMMUNITY BENEFITS FROM POWER POOLING

Thus far, this paper has dealt with the more technical aspects of pooled systems. Other features are beneficial to the community from a different point of view. One of these is that the method allows freedom in the choice of site for manufacturing establishments, great and small. Power, in unlimited quantities, to all intents and purposes, can be supplied at any point in the eastern Michigan area that is practicable for factory use.

Economical power generation from fuel requires condensing

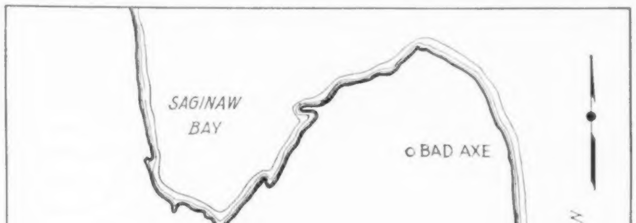


FIG. 5 TERRITORY SERVED BY THE DETROIT EDISON COMPANY

water in great quantities. Although the Detroit and St. Clair river system with its flow of 160,000,000 cfs affords a supply of water that is sufficient to serve generating plants of practically unlimited capacity, all sites which might be available on the water front would soon be preempted if all of the manufacturers who are located in the region were compelled to build generating plants on the river, and a great natural asset would be wastefully used.

The Detroit Edison Company's four major steam plants are located as shown in Fig. 5. Two are in the City of Detroit proper, one is about 60 miles north on the St. Clair River, and a fourth is 20 miles to the south near the mouth of the Detroit River. These plants are capable of considerable expansion. A fifth site has been purchased on the Detroit River but is as yet undeveloped. While these five sites occupy a combined river frontage of not more than 1.38 miles, they can be developed to a total generating capacity of 2,000,000 kw, or more than twice that of the existing system. The opinion is strongly held, however, that individual powerhouses should be limited in size to about 350,000 or at the most 400,000 kw. This is based on considerations of good administration and upon a reluctance to concentrate too large a proportion of the system capacity in a single house lest some major disturbance, which might shut down an entire power house, pull down the whole system.

Two of the most important factors limiting the practicable capacity of a given location are the physical conditions governing the routing of transmission lines away from the switching station and the availability of space for receiving and stocking coal, the fuel resources of the Detroit area being what they are. Yards of present plants are large enough to permit stocking much more than the 500,000 tons, which it has been the long-standing practice to accumulate for the winter. Marysville, Conners Creek, and Delray receive coal by self-unloading barges loaded at Lake Erie ports, and, by the time lake navigation closes in December, the stock piles of these plants contain coal enough to supply them throughout the 17 weeks when ice fills the rivers and prevents movement of vessels. When navigation is resumed in the spring, the practice has been to have approximately 30 days' supply remaining in the yards as a reserve against vicissitudes of coal mining and shipment or as the result of overcareful provision against the vagaries of an unpredictable cycle of power demands.

POOLING REQUIRES TRANSMISSION AND DISTRIBUTION SYSTEMS

Concentration of power sources in several large plants and their location on deep water to give them the advantages of lower transportation costs on fuel and the incomparably greater advantage of high-vacuum turbine operation have been described. An inherent drawback of both practices is that the economies of such a system are, in some degree, offset by the considerable investment costs of an elaborate electricity-distribution system and operating and maintaining it. This transmission and distribution network is an inevitable part of a pooled generating system and its relatively small number of highly efficient generating units. Design of this electrical network must satisfy two fundamental requirements. It must provide (*a*) an economical means for supplying any loads that may develop in the area served and (*b*) service of high quality despite any hazards that the system itself imposes.

The following description of electrical transmission in the Detroit area illustrates one method of meeting these requirements. Energy from the Company's power plants is transmitted to a number of bulk-power stations, each supplying a group of smaller local substations. Large demands for power can be supplied directly from the bulk stations, while smaller loads are served by the local substations. The geographical locations of these stations are such that any demands for power that industry is likely to make can be quickly accommodated.

The interconnection of the units of any electrical system requires careful engineering. On one hand, ties must have sufficient capacity to permit operation of the system as a unit and to supply sufficient help to any area where a shortage of capacity develops. On the other, if system interconnections are promiscuous, short circuits will develop which cannot be handled by available switchgear, the control of power flow through the system will be difficult, and a failure in one area will seriously affect service throughout the entire network.

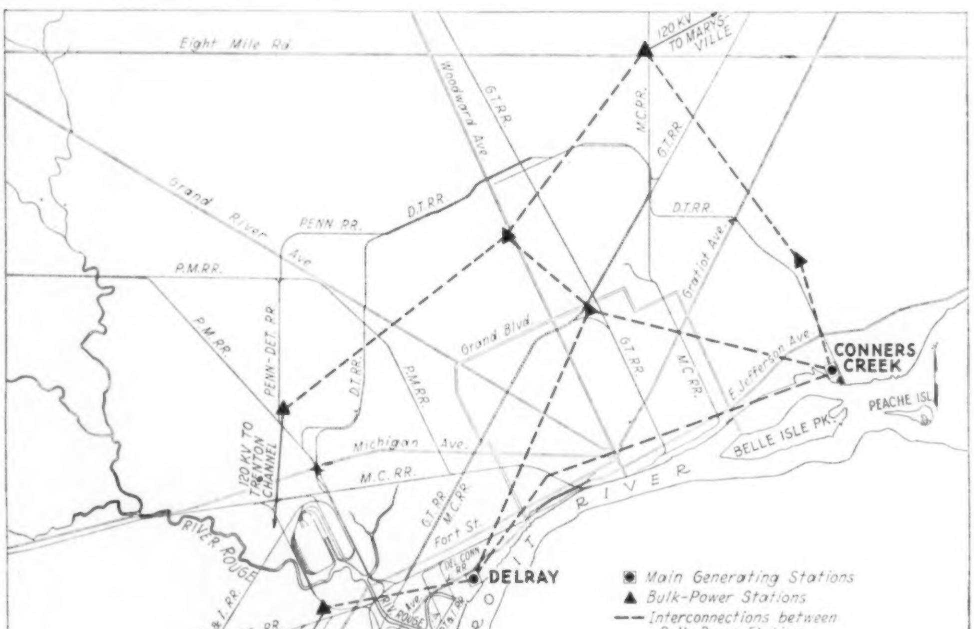


FIG. 6 MAP OF DISTRIBUTION SYSTEM IN THE CITY OF DETROIT

(The bulk-power stations are represented by the solid triangles. Interconnections between them are indicated by the heavy dash lines and provide for an interchange of power that is relatively easy to control. This arrangement gives a "loose-linked" system that divides the entire territory into five self-sustaining power areas, the equivalent of that number of independent but contiguous interconnected power systems.)

The Detroit Edison Company operates with a type of system interconnection that may be described as "loose-linked." By this method, each power plant normally supplies a definite load area through one or more bulk-power stations and their connected substations. Sufficient spare capacity is installed to provide against electrical failure of transmission and station facilities. As their boundaries can be adjusted from time to time to match the capacities of the generating stations, the areas are self-sustaining. Limited-capacity ties are provided which may or may not normally carry load but which are sufficient in capacity to compensate for any losses in generating capacity which can be reasonably anticipated. Operation of this loose-linked system is very similar to that of a group of independent but contiguous interconnected systems. Because the ties are few in number and limited in capacity, flow of short-circuit currents between areas is limited. As the interconnections are made between bulk-power stations, interchange of power between areas is in bulk and relatively easy to control. In the event that an uncontrollable fault develops in one area, the remainder of the system cuts clear and carries its load just as any group of adjoining communities, electrically interconnected, would separate themselves from one where serious trouble developed. Fig. 6 shows the bulk-power stations in the City of Detroit and their interconnections.

In the main, the suburban area around Detroit is served by a group of bulk stations that are supplied from a 120,000-v tower line which encircles the city and terminates at the Marysville power plant at the north and the Trenton Channel plant at the south. As shown in Fig. 6, these two plants also supply bulk stations located on the edge of Detroit. Although, at present, only about 20 per cent of the total system load is in the suburban area, the quantity that could be economically furnished with the existing transmission and distribution technique has practically no limitation.

The Detroit Edison system is interconnected with that of the Consumers Power Company on the west, with the Mistersky power station of the City of Detroit, and with certain large industrial plants. These interconnections provide mutual support with a resulting reduction of reserve generating capacity that must be provided by each of the interconnected systems.

LARGE BLOCKS OF POWER AVAILABLE FOR INDUSTRY

Investment in transmission and distribution plant is large, amounting in the Detroit system to $159,381,000, or approximately 56.6 per cent of the total property, as compared with 34.5 per cent for the investment in power plants. The case is analogous to the manufacture and sale of automobiles and all products of modern manufacturing that are distributed nationally. Lowered cost of mass production and more effective use of manufacturing facilities must justify increased cost of distribution and sale, and the spread between the cost to produce and to the consumer becomes relatively great. A wholesome corrective in the interest of consumers of electricity is that so considerable a portion of a central system's output is sold to wholesale users under conditions that are always potentially, and often entirely, competitive. Under such circumstances, if the fact is known that the large industrial users on one hand and the numerous groups of commercial and residential users on the other are being made to bear their fair share of the common investment and operating costs, the competitive nature of one class of service gives some assurance of the correctness of the rates charged the noncompetitive group.

Mention has already been made of the necessity, which is felt by the management of a rapidly growing central system, of anticipating unexpected load increases by overbuilding both plants and system. As a corollary to this, the purchaser of electricity needs to exercise considerably less forethought as far as his power requirements are concerned. Increases that are large in the eyes of the individual consumer are small in comparison with the central system. The availability of a sufficient supply of power on short notice and, if necessary, in large blocks is no insignificant asset to an industrial community like Detroit.

Frequently, industrial loads are of a character that would be difficult for an isolated industrial plant of an ordinary capacity to handle. Many of the welding loads cause violent current fluctuations, to mention one process whose importance in automobile fabrication is growing rapidly. This is true also of electric-melting furnaces and the great continuous-strip rolling mills now in use in the Detroit district. One such load, that of a rolling mill, is illustrated by the load curve reproduced as Fig. 7, which indicates variations of 30,000 kva in a matter of a few seconds. These load surges produce voltage and frequency disturbances that are greater in severity the smaller the plant, and they may even cause unstable operation of generators. Although the effects of these loads can be noted even on a large central-station system as in Detroit, they are minor and usually do not require extraordinary handling. The load shown in Fig. 7 causes the system frequency of the Detroit system to dip one tenth of a cycle and, by watching the curve-drawing frequency meter at one of the power plants, the intervals at which billets are passed through one of the large rolling mills can be readily observed. Voltage dips, caused by fluctuating loads like this, would be of more detrimental effect if uncompensated for. When the fluctuations are of such magnitude as to be felt at the power-plant busses, voltage regulators installed in one strategically located plant have proved sufficient to obviate any ill effects.

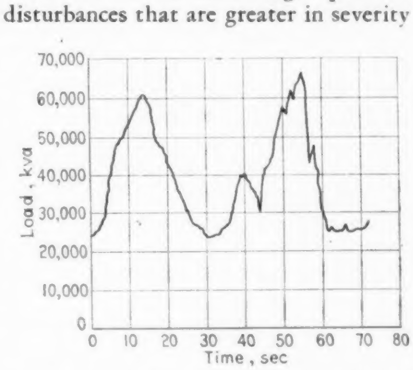


FIG. 7 WIDE FLUCTUATIONS IN DEMAND FOR ELECTRIC POWER MADE BY A SHEET-STEEL PLANT

(Variations of 30,000 kva in a few seconds, such as are shown, would produce voltage and frequency disturbances that would cause trouble in an isolated plant, but, in a large system, these peaks are handled without excessive trouble. This curve is typical of the demands for power from industrial plants in the territory served by The Detroit Edison Company.)

With all its advantages of both reliability and economy, the central system cannot, under certain circumstances, compete with certain types of load. Combining electric generation with a supply of steam required in some industrial process, produces power as a by-product at a much lower cost than can be attained by the best of condensing turbines. Seldom, however, does the requirement of steam for process work and building heating coincide with the manufacturer's own use of power. Paralleling such by-product generation with the central system may be, and often is, good economy rather than providing spare capacity against breakdown or being compelled to generate power under costly conditions in periods when no corresponding demand for steam exists. In a sense, the central system becomes a broker ready to sell or buy power as the circumstances of the moment may dictate.

EXPERIENCES *in the* EARLY DAYS *of* ELECTRICITY

By ALBERT MILMOW

SALES ENGINEER, CHARLOTTE, N. C.

I COME before you tonight as an electrical man and as such I must acknowledge a debt to the mechanical engineers. If it is not disloyal, I might say that my business is the handmaiden of yours, because nearly all electricity has its origin in mechanics and its ultimate application to the needs of man is also through mechanics. This is as true of the primitive telegraph with its pivoted sending key and its chattering sounder as it is of gigantic turbines and the motors and intricate controls and the lights that they operate. It is after all, a wonderful, partly mysterious, and immensely flexible transmission system for the work of your minds. Perhaps, to think of it as your partner, competent and powerful, allowing you to expend your work almost infinitely would be more nearly accurate.

Not only in the matter of machines does our tradition go back to unite with yours, but in men also. I recall that at Schenectady in 1894 when we were just beginning to be important as an industry, I was very curious as to where our engineers had acquired their knowledge of the subject. I found most of them to be mechanical engineers by education and training who had adopted the new art. They obtained their knowledge of the fundamentals of electricity from the scientists, the inventors, the experimenters, and from their own trials and errors. It is interesting at this point to recall that electricity is the industry most scientifically based from the beginning. It came at a time when science was fairly well established and its investigation fell into the hands of trained scientists who reduced the results of their investigation to correct mathematical formulas which are used today as the basis for electrical calculations. Such men as Ohm, Ampere, Volta, Faraday, Kelvin, and Steinmetz contributed scientific methods to the theory of electricity. To illustrate this point, I had occasion, not long ago, to report on the possible improvement in efficiency of a textile plant which was equipped with large motors about 25 years old. The first step in the investigation was to determine the efficiency of these motors. To my surprise, I found that it was between 91 and 92 per cent, as good as can be obtained today.

THE HIGHEST HYDROELECTRIC PLANT IN THE WORLD

To men in this country engaged in engineering, in recent years, with all sorts of facilities at hand or near by, to hear about experiences late in the last century and early in this one, and in remote places may be interesting; I might say on the "frontiers of industrial development." My first work after leaving Schenectady in 1899 was in Peru, where I was electrical engineer for a large smelter. It was located in the Andes at 13,500 ft elevation and the plant was operated by several Pelton impulse wheels operating under a head of 800 ft. While there I installed several small Pelton type hydroelectric plants. Possibly the most notable was a 15-kw direct-current installation at an altitude of 16,200 ft, the highest in the world at that time and possibly so even today. It operated from a small lake on the mountainside which was fed from a melting glacier, and was about 700 miles south of the equator.

My next work was at Quito, Ecuador. This was a city of about 75,000 people located about 250 miles inland at an altitude of 10,000 ft and practically on the equator. The route to Quito was by river steamer for one day's journey, then, in the rainy season, about one day's journey in canoes, along submerged pack trails, through the jungle; then by muleback the rest of the way, over a pass 16,000 ft high and down again into the Andean Valley. I describe the route to show the difficulty of transporting machinery. When possible, the machinery was made for muleback transport; no piece weighing over 250 lb, but large pieces like armatures or the runners of water wheels had to be skidded, rolled, or actually carried by hand.

WIRING AND MAKING REPAIRS DIFFICULT IN ECUADOR

The city was wired by inserting crossarms in the adobe walls of the buildings and zigzagging across the streets. This was necessary as the streets were too narrow to permit placing poles, and balconies overhung the streets, in places almost meeting in the middle. The zigzagging was to protect the balconies against sagging wires. The plant was hydroelectric, with Leffel-Sampson turbines.

In all the city not a machine shop nor a blacksmith shop except of the crudest sort was available. Probably 95 per cent of the people had never seen a steam engine, a railroad, or a steamship. The nearest help in case of trouble was Lima, Peru, about 30 days distant. Under such circumstances, breakage of even the simplest iron part became tragic. I had a generator with a slightly bent shaft. It burned out one coil per month and to repair this was a 24-hr job, but that is what I had to do. Some of you might have been able to straighten that shaft with no means of doing it, I did not even try. A native attendant broke a tooth out of a pinion in the gate gearing. I had to cut a seat for a new tooth with an old hacksaw, beat a piece of iron into crude shape, fit it into the seat and file it down to the semblance of a tooth. I do not remember just how long this took me, but it was a long, long time.

The sheet-iron penstocks, about 42 in. in diameter, terminated in brick forebays about 25 ft high. We were short of water and the president of the company conceived the idea that, by increasing the height of the forebays, a greater head and more power might be had. I refused to do it. He referred the problem to a college of Jesuits, who were good theoretical men but lacked practical experience. They agreed with him, but I still refused. Then I was called away on a trip and on my return found the city in darkness. Hastening to the plant, I found the forebays had collapsed and my penstocks were mashed as flat as a pancake. They had run the

Presented before the Charlotte Section of The American Society of Mechanical Engineers, Sept. 25, 1936, Charlotte, N. C.

brickwork up, while I was away, and the penstocks would not stand the additional pressure. We rebuilt them with stave pipe, all made by hand, but were shut down for about three months. Don Manuel listened to me after that as long as I was with him.

EXPERIENCES IN THE PHILIPPINE ISLANDS

My next plant, almost half around the world, was at Iloilo, Panay, Philippine Islands. It had three 150-hp Harrisburg engines belted to 100-kva generators, four Sterling boilers, and condensing equipment. I went to install the electrical part only, but on arriving was told that I would have to install it all. I said that I would try if they could not get anyone who knew more than I. Conditions there were better. We did have a machine shop and the steamers came in bringing with them that grand old race of men, the marine engineers. It was all pretty new and strange to me. I found a tube expander among the tools and had no idea what it was for. When I came to put the tubes in the boilers, I did not know what was to hold them in place. Then a great light dawned on me as I mentally connected them up with the strange tool I had found. The only remaining problem was to find out how to use it. I did this by visiting a steamer, with a worthy Scot as chief engineer, and presenting him with a bottle of Scotch, which we opened on the spot, and I soon departed with the desired information. I had to lay all the firebrick in the boiler setting myself and had to prospect in canoes for fire clay. We had nothing like evaporators. The water was brackish and unfit for use in boilers. The only make-up we had was rain water caught from the roof in brick cisterns. In the rainy season we were at ease, but the smallest steam leak in the dry season was a tragedy.

There I learned the use of the capstan. It was mounted on a framework and, with five or six husky natives and blocks and tackles, made a very good substitute for a donkey engine, though slow. We whipsawed all the lumber from logs floated down the river and it was crude lumber. Beams were shaped with adzes. Scaffolding was of bamboo. The stack, about 42 in. in diameter, and 110 ft high, was too light to raise with a gin pole, even if we had had one, so it was riveted in place, section by section, from a bamboo scaffold. This construction I had to do myself and as the scaffold swayed in the wind, I hit my hand with the hammer about as often as I hit the riveting tool. It was with a great sense of relief that I climbed down for the last time after riveting on the top ring. This plant operated well and successfully. Time does not permit any comments on the electrical part, they were tame experiences compared to the mechanical part. Neither can I take time to comment on the interesting old Spanish plant in Manila where I worked for some time. Instead, I will go on to a "new frontier."

SALES WORK PLAYS AN IMPORTANT PART IN TECHNOLOGICAL ADVANCE

I left construction work and went into sales work. To tell the supremely important part that sales work has played in forwarding technological advance is difficult to realize and a long story in itself. People have to be shown and persuaded and sometimes bullied and pestered into adopting a new idea. As an illustration of this, the statement has been made that if all the present policies and plans of insurance companies were available, as they are now, but only in the insurance offices, and if no agents were employed, only about 10 per cent of present insurance would be in force. Remember this when the next insurance man calls on you.

After about six years in foreign work, I arrived in the Carolinas in 1906. In 1908 I became connected with the Southern Power Co., parent of the present Duke Power Co., as engineer of the mill power department and in charge of the sale of power and design of industrial drives. One plant was then in operation near Rock Hill and another was being constructed at Great Falls. At that time the Corliss engine was used almost universally to operate textile plants. It had reached a high state of perfection and was a fine piece of machinery. The mill men regarded their engine plants with affection and took pride in them. They told some good stories about how cheaply they could make power, especially when we were trying to sell them. These conditions rendered it hard to establish a competing form of power, the advantages of which were intangible and could be demonstrated only by use. In addition we were asking mill men to trust their precious production to a mysterious agency coming to them, over the red hills and through the forests, on three small wires. A word of tribute should be paid here to the forward looking executives who were the first to sign up.

RATES REDUCED TO SECURE CUSTOMERS

We had to resort to low rates to get our power accepted at all. This was accomplished by making secondary-power rates. We contracted to supply a mill with power when we had the water at about $^1/_2$ cent per kwhr and guaranteed to do so for at least six months out of the year. For power guaranteed for eight months the rate was higher, and finally primary power which was guaranteed continuously paid a still higher rate. The inducement in the secondary rates was that the mill men expected to get the power at the low rate for a period longer than the guarantee, while we were selling our capacity, and they did in most cases.

This secondary power involved arranging the mill drives in such a way that they could be quickly changed from steam to electricity and back again. It was accomplished by uncoupling the main line shaft on both sides of the main driven pulley and at other convenient places along the shaft. Motors were then lined up with the disconnected sections, or with smaller groups by extending countershafts. When changing over, the uncoupling would be made, belts were put on the motors, and the change was made, in most cases, quickly and with surprisingly little trouble. We had to contend with a few plants, steam-electric driven, employing 40 cycles where our power was 60 cycles. Among other devices to care for the situation was the motor-generator set. I have recently heard of a case where a power company sold for \$3500, for junk, a set costing \$85,000—one of the hazards of which amateurs rushing into the power business at the taxpayer's expense, are blissfully ignorant.

The secondary-power drives demonstrated two things, both intangibles, about purchased power. One was higher production, together with improved quality, due to more constant speed and more uniform angular velocity, as compared with a reciprocating engine. The other was that all mills were at some time unbalanced with respect to departments and a backward department could be operated overtime, thereby keeping production in balance. These two important factors in production being demonstrated and reasonable continuity of service being proved, newly constructed mills were equipped for primary power exclusively. Many mills that had kept steam plants in reserve were willing to abandon them. I recall one case where electric power displaced a Corliss engine three time, first at Clover, then at Cherryville, and then at Burlington, retreating before the advance of the power lines. Where electric power was used from the start, mill design was pro-

(*Continued on page 344*)

HYDRAULIC GENERATION *of* POWER

Turbine Types and Their Fields; Factors Influencing Power Costs

By R. R. ROBERTSON

ENGINEER OF CONSTRUCTION, LOS ANGELES BUREAU OF POWER AND LIGHT

A HYDRAULIC power plant consists mainly of a means of delivering available water under pressure to a site, machinery and equipment to produce the power, and the necessary setting or foundation, including the building required. Water for supplying the plant must be collected in a suitable forebay and, in the case of high-head plants, as a rule, must be conducted considerable distances in canals or tunnels. It is conveyed from the forebay to the turbines through steel pressure pipes or penstocks, which should be as short as possible for economic and operating reasons but will vary considerably in length depending upon the plant location. Low-head plants located near the source of supply, such as are commonly found in the eastern and central portions of the country on large rivers, have relatively short penstocks of large diameter. High-head plants, such as are found in the West, where as a rule water is taken from smaller streams in rough country, have penstocks of considerable length and relatively smaller in diameter.

The design of penstocks for high-head plants is much more complex than for low-head plants. Determining the economic diameter is most important from the standpoints of construction and operation. In general, the economic diameter is that for which the sum of the interest and depreciation on the first cost of the line and the annual value of the power lost in pipe friction will be the minimum. This can be calculated by a number of methods and formulas. Two of these, which are commonly used, are given by Dr. W. F. Durand, in "Hydraulics of Pipe Lines,"[1] and by Dr. D. W. Mead in "Water Power Engineering."[2] A very practical and accurate graphic method for finding the economic diameter of a penstock has been worked out by H. L. Doolittle, chief designing engineer of the Southern California Edison Company, and was described in MECHANICAL ENGINEERING.[3]

FIRST ALL ELECTRICALLY WELDED PENSTOCK

In 1932, the first all electrically welded penstock was installed by the Los Angeles Bureau of Power and Light at its San Francisquito Power Plant No. 2. Prior to this, riveted pipe and hammer- or forge-welded pipe was used. For riveted pipe, the usual type of joint, such as is used in boiler and pressure-tank construction, was the practice. For economy in transportation and handling, except where the plant was located at a convenient distance from a railroad, all assembling and riveting was done at the site. The hammer-welded pipe was necessarily fabricated in the manufacturer's shops in lengths of about 20 ft. End or circumferential joints were of the "bump" type, in which the connecting rivets were out of the line of water flow. For sections of the line where plates of greater thickness were required, welded pipe was more economical because the increased shipping and handling cost was more than offset by reduced weight due to greater joint efficiencies and by decreased diameter made possible by less water friction due to the absence of rivet heads and splice plates, common in riveted pipe. Welded-joint efficiencies of 90 per cent were guaranteed by the manufacturers, and many tests have shown the weld to be practically as strong as the plate.

The application of arc welding to penstock construction has been brought to its highest development in fabricating the penstocks for the Boulder Canyon power plant.[4] These pipe sections were fabricated in a special plant, built at the site, because the large size of pipe required made shipping fabricated sections from the home works impossible. These varied from $8^1/_2$ to 30 ft in diameter and from $^5/_8$ to $2^3/_4$ in. in thickness, and some of the 30-ft sections, as fabricated, weighed 150 tons.

Plates for these sections, measuring 12 ft × 32 ft × $2^3/_4$ in., as large as a flat car could carry, and weighing 22 tons each, were shipped from the mills, two to a car. Three of these plates were fabricated into one 12-ft section requiring three longitudinal welded joints. The entire contract required 4700 ft of 30-ft and 1900 ft of 25-ft pipe for headers, 5800 ft of 13-ft pipe leading to turbines, and 2000 ft of $8^1/_2$-ft pipe leading to needle valves, and the total tonnage was approximately 45,000. All pipe sections were stress-relieved in oil-fired ovens, maintained automatically at 1200 F for periods of time depending upon the thickness of the plate. After this, the temperature was reduced for a 3-hr soaking period to 600 F.

Where changes of alignment are required, bends to a radius of four or five times the diameter of the pipe are customarily made. In riveted bends, the common practice is to make the maximum angular change in any one plate not to exceed 5 deg. In the welded pipe, changes of direction were usually made with cast-steel elbows or welded bends formed by cutting out about two thirds of the circumference of the pipe, in accordance with the 5-deg limit and welding together after bending. For angles up to 5 deg in welded pipe, the bump joint formed

[1] "Hydraulics of Pipe Lines," by W. F. Durand, D. Van Nostrand Company, Inc., New York, N. Y., 1921, pp. 212–218.

[2] "Water Power Engineering," by D. W. Mead, McGraw-Hill Book Company, Inc., New York, N. Y., 1915, pp. 546–550.

[3] "A Method for the Economic Design of Penstocks," by H. L. Doolittle, MECHANICAL ENGINEERING, Mid-November, 1924, pp. 785–792.

Presented at a meeting of the Los Angeles Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Dec. 1, 1936, Los Angeles, Calif.

[4] "Penstocks for Boulder Dam," by C. M. Day and Peter Bier, MECHANICAL ENGINEERING, pp. 451–465. Also: "Hydraulic Valves and Gates for Boulder Dam," by P. A. Kinzie, MECHANICAL ENGINEERING, vol. 56, 1934, pp. 387–408.

in a spherical manner instead of a straight taper can be employed.

To control pipe movement caused by temperature changes, lines are sectionalized by heavy concrete anchors completely enclosing the pipe and bonded to it by anchor rings or existing circumferential joints. End movement is permitted by the common slip-type expansion joint made either by pipe sections with suitable stuffing boxes or by an individual cast-steel joint introduced into the line by companion flanges. General practice is to install expansion joints midway between anchors on flat slopes and directly below the upper anchor on steep slopes. The packing used is usually square braided hemp or flax impregnated with graphite.

In ordinary practice, where the line slope is not over 30 deg, concrete piers are spaced approximately 20 ft apart; on steeper slopes, this spacing is increased. To reduce friction and wear, which would result if the pipe were supported directly on the concrete of the piers, cast-iron or structural-steel metal saddles are provided and arranged for lubrication either by grease or by inserting a piece of roofing or some other paper which is suitable.

To prevent collapsing of pipe due to a vacuum caused by water rushing out because of a break at some point in the line below, automatic air-inlet valves are provided. Ordinarily, these valves are located at the upper ends of sloping sections of the line and are also arranged to discharge air from the line when it is being filled. To care for the effect of sudden changes of load, surge tanks are necessary in connection with long penstock lines.

Shutoff valves for emergencies or for use when maintenance work is being done on the line should be installed at the upper ends of penstocks. These valves are usually of the butterfly type and are arranged for remote closing from the plant in case of emergency.

FIELDS AND OPERATION OF REACTION AND IMPULSE TURBINES

Hydraulic turbines are divided into two general types, (*a*) reaction turbines and (*b*) impulse turbines. The essential difference between the two types lies in the method of using the available head. Water enters reaction-turbine runners after only a portion of its energy has been converted into velocity, that is, it enters under pressure. On the other hand, water strikes impulse-turbine buckets under atmospheric pressure after all of its energy has been converted into velocity, the wheel's speed being such that the water drops dead when leaving. The most commonly used reaction turbines are of the Francis or inward radial-flow type. In American practice, Francis type turbines now used in many cases might be called mixed-flow turbines because water flows both in a radial direction and parallel to the shaft. Impulse turbines of modern design are horizontal-shaft machines. Reaction turbines can be of either the vertical- or horizontal-shaft type, although in the more recent installations, probably for reasons of economy, the vertical unit seems to be more common.

Reaction turbines are in general the more efficient. However, this type is not considered suitable for heads greater than 800 ft and generally is used under considerably lower heads. Impulse turbines are generally used for heads above 800 ft and the maximum head in any plant, so far as is known at this time, is 4850 ft in a 3000-hp plant at Fully, Switzerland. Probably the highest head used in this country is 2400 ft, at the Big Creek No. 2-A plant of the Southern California Edison Company. For all practical purposes, average efficiencies for impulse and reaction turbines are 82 and 90 per cent, respectively, although both values have been slightly exceeded in some recently constructed plants.

To take care of possible pressure rises that might be dangerous to the penstock, some means of relief must be provided at the turbine. This is accomplished by a governor-controlled relief valve for reaction turbines and by a by-pass nozzle working in synchronism with the power nozzle for impulse turbines. In both cases, water is temporarily spilled until conditions are again normal. Where a constant flow must be maintained through a plant, as for example, where conformity to irrigation conditions farther downstream is necessary, the relief feature can be combined with a synchronous by-pass so that the flow is kept constant regardless of the load.

Speed control on reaction turbines is maintained by governor-actuated wicket gates that restrict or increase the flow of water from the spiral casing to the runner. In impulse turbines, this is accomplished by moving the needle to change the orifice cross section of the power nozzle. This can also be accomplished by a ring deflector, through which the power jet normally passes, operating to deflect the jet from the wheel temporarily. This operates in synchronism with the power nozzle and returns to normal position after the nozzle needle has been safely adjusted by the governor to the proper position for the new load.

Draft tubes are used in connection with reaction turbines and have the advantage that, while the entire available head can be used, the turbine can still be set high enough above the tail-water level to allow inspection and maintenance without draining the tail bay. Practically, the draft head should not be greater than from 12 to 15 ft to prevent the water column breaking with the accompanying disturbance due to such a condition.

Spiral casings for reaction turbines have formerly been made of cast iron or cast steel, depending upon the head. In the last few years, some spiral casings have been made of riveted steel plates and, with the more practical and common use of arc welding, many cases, in the future, will be built of welded steel plate.

Shutoff valves between penstock and high-head turbine have usually been of the needle or plunger type arranged for smooth streamline control of water flow and operated, through suitable controls, by penstock pressure. When these valves were being used, butterfly valves were looked upon with suspicion and were considered safe only for low pressures. Even then, they were considered only as the lesser of two evils as compared with the sliding leaf gate valve. Recent developments have brought butterfly valves to the fore, and, due to their considerably lower cost as compared with the plunger-type valve, they are beginning to be widely used for high-head work. Formerly, a butterfly valve could not be made tight except by hand adjustment of the seats after closing. The large 13-ft turbine-shutoff butterfly valves installed with the first four large units at Boulder, when tested under a pressure of 450 lb per sq in. after normal closing, showed leakages of only 50 gpm, which is remarkably good for so large a valve.

The Boulder Power Plant, one of the largest hydroelectric plants in the world, is designed for a total capacity of 1,317,500 kva, through the ultimate installation of 15 main generating units of 82,500 kva capacity each and two 40,000-kva main generating units. Articles describing the turbines,[5] and generators were published in MECHANICAL ENGINEERING and no description of them has been included for that reason.

The following general statement or outline covering the cost

[5] "Boulder Dam Generators," by L. N. McClellan, MECHANICAL ENGINEERING, vol. 56, 1934, pp. 409–414. Also: "Turbines for Boulder Dam," by I. A. Winter, MECHANICAL ENGINEERING, vol. 56, 1934, pp. 415–425. Also: "The Construction of the 115,000-Hp Boulder Dam Turbines," by W. M. White, MECHANICAL ENGINEERING, vol. 57, 1935, pp. 539–546.

of power is quoted from "Water Power Engineering"[6] by Dr. D. W. Mead:

The cost of water power depends on:

First: Cost of financing including discount on stocks and bonds, interest during construction, cost of management and engineering, and fixed and operating charges until the plant shall reach a paying basis.

Second: The investment in real estate, water rights, power plant and equipment, transmission lines, substations, distribution system, and other physical features, and the interest which must be paid thereon.

Third: On the loss from the depreciation of the various elements of the plant, the cost of maintenance and repairs, the cost of contingent damages from floods or other accidents.

Fourth: The operating expenses including labor, oil, waste, and other station supplies and expenses, including also, in hydroelectric plants, the patrolling and maintenance of the transmission lines and distribution system.

Fifth: The expenses for taxes, insurance, etc.

The total annual cost due to the above sources of expense is the annual cost of the power furnished by the plant, be the quantity of that power much or little.

Due to the fact that water-power sites are where they may be found, the cost of power produced can hardly be the same for any two sites. Conditions of development and distance from market are bound to be different so that no general statement can be made as to the cost of generating hydroelectric power that will hold for all cases. Costs per horsepower will also vary considerably with capacity and head. In one case, the estimated cost per horsepower for a 50,000-hp plant was nearly 30 per cent higher than for a 100,000-hp plant at the same site. In another case, where two plants of the same capacity were constructed under similar conditions except that the head was 18 ft in one case and 80 ft in the other, the cost per horsepower for the former was about 85 per cent higher than that for the latter.

To give some idea as to the cost of hydroelectric power, the Boulder Canyon Power Plant is taken as an example. The figures given in Table 1 are general, being quoted from the publication[7] by the Colorado River Commission of the State of California. They are based on a report which was prepared by R. N. McClellan, chief electrical engineer of the U. S. Bureau of Reclamation.

TABLE 1 ANNUAL COST OF BOULDER DAM POWER AT TERMINAL STATION NEAR LOS ANGELES

Assumptions

Power generated at dam—3,600,000,000 kwhr
Power at terminal station (12 per cent loss)—3,168,000,000 kwhr
6-circuit transmission line
Cost of falling water at dam, as per contracts—1.63 mills per kwhr
Load factor—55 per cent
Cost of fuel oil—$0.70 per bbl
All power transmitted by one agency

Cost of falling water, under contract, 3,600,000,000 kwhr at 1.63 mills	$ 5,868,000
Generating-plant costs based on cost of plant, including interest during construction, $21,053,649, estimated interest, amortization, operation and maintenance, and depreciation	1,943,308
Transmission costs, based on total cost of line, equipment, and terminal station, $48,260,000	3,917,000
Steam stand-by costs, based on installed capacity of 58,000 kw., $0.70 oil, and 55 per cent load factor, $4,495,000	518,000
Transmission line from steam stand-by to terminal station total cost, $2,725,000	171,000
Total annual cost at terminal station	$12,417,308
Cost per kilowatt-hour, mills	3.92

[6] "Water Power Engineering," by D. W. Mead, McGraw-Hill Book Company, Inc., New York, N. Y., 1915, pp. 669–670.

[7] "Colorado River and the Boulder Canyon Project," by the Colorado River Commission of the State of California, San Diego, Calif., 1931. Report by R. N. McClellan, p. 176.

TOPICS SUGGESTED FOR STUDY AND DEVELOPMENT

The following items are suggested as possibly being worthy of further study and development in the interest of improved efficiency and performance of hydroelectric generating units:

(1) Investigation of pressure-regulation equipment, including energy-absorbing devices and materials for same

(2) Promotion of the use of, and such refinement of design of, adjustable runners as will make for more common use of such equipment in variable-head plants

(3) Further attention to the design of impulse-wheel housings looking toward a more complete dewatering of the buckets in an effort to improve efficiency

(4) Adaptation of improved metals, such as stainless steel, to turbine parts, such as wearing rings where small clearances are important, together with improved methods of correcting the effects of pitting. Complete and thorough tryouts of applying such metals by the spraying process

(5) Development of suitable designs for electrically welded spiral casings for high-head turbines which can be substituted for the heavy and expensive steel castings now used

(6) Application of hydrogen cooling, such as is now used in condensers and similar equipment, to hydroelectric generators.

Experiences in the Early Days of Electricity

(Continued from page 341)

foundly affected. Formerly, a motive power and its connecting system of shafting was laid out and the machinery arranged to conform to it. Now, the building and machinery are the prime considerations in design and motors can be adapted to conform. This made a much cheaper and more efficient manufacturing plant. The old shafting drives were subject to certain definite limitations, such as length, angles through which they might not be efficiently turned, and length of belt and rope drive.

ELECTRICITY AFFECTS AN ENTERPRISE'S ENTIRE PHYSICAL AND FINANCIAL STRUCTURE

Much more is involved than simply turning a shaft, with a reciprocating engine in one case and turning it a little better with a motor in the second case, but electricity is a factor affecting the whole physical and financial structure of an enterprise. The same thing is true about most of the applications for electricity. The ultimate and indirect effects go far beyond the immediate and apparent.

Mr. Stuart Cramer of Charlotte invented the four-frame drive. This was a motor with shaft extended at each end and two pulleys on each extension, permitting it to drive four spinning frames without the intervention of any shafting. The individual motor for spinning was rather laggard in application, although installed here as long ago as 1909. This was due to several things. Direct connection was too rigid and did not permit speed changes. Gear drives were rather noisy and were costly to maintain. Chain drives were satisfactory but presented oiling difficulties. With the advent of V-belt or tex-rope drive, the individual motor for spinning was fully accepted. Bearings of every kind were tried. Lint would siphon the oil from the oil-ring bearings. Waste-packed bearings did very well in small sizes. The complete answer seems to be in the modern ball bearing, although we suffered many failures with them due to faulty design or assembly or lubrication. The individual motor for looms has been used since about 1913 on a commercial scale. We went through a long process culminating in the present-day, totally enclosed, waste-packed bearing type of motor with high inertia rotor which is now standard and satisfactory.

RUBBER SPRINGS

Design Calculations—Some Representative Uses

By WALTER C. KEYS

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$\delta = \frac{PL}{AE}$

PURE rubber, like pure iron, is almost never used for structural purposes. Like iron, rubber can be "alloyed" or compounded with scores of other ingredients into an unending variety of "compounds," hereinafter referred to as rubber. When subjected to a temperature of about 300 F, the physical properties of rubber compounds containing sulphur, and certain other ingredients, become stabilized. This process is known as vulcanization, during which the compound is usually confined within a metal mold and subjected to a pressure of several hundred pounds per square inch.

Like water, rubber is practically incompressible. However, for convenience, rubber is said to be compressed when it is subjected to compressive force. Rubber can be stressed in compression and in shear, which properties are usually employed in structural applications. It can also be stressed in tension and flexure, which properties are used infrequently.

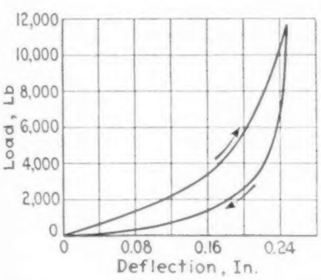

FIG. 1 LOAD-DEFLECTION CURVE OF A RUBBER DISK

(The dimensions of the disk are O.D., $2^1/_4$ in.; I.D., 1 in.; and thickness, $^1/_2$ in.)

Similarly to gases being compressed, rubber passes through a heat cycle when it is deformed. This is illustrated in Fig. 1, which shows a typical load-deflection curve. The area of the loop represents heat released within the rubber. Since rubber is a very poor conductor of heat, its temperature will rise when it is excessively, repeatedly, and rapidly deformed. Perhaps the most familiar example is the rise in temperature of automobile tires at high speeds. Cases are known where underinflated pneumatic tires have ignited and where badly overloaded solid tires have exploded. This indicates that rubber, like any other material, must be used correctly to give satisfaction.

Properties of high-grade rubber compounds, as given in Table 1, are typical.

CALCULATION OF RUBBER SPRINGS

(1) TENSION

While not extensively used for springs, rubber in tension has been used for airplane landing-gear shock absorbers and may, in other cases, be found advantageous. The approximate value of the tension modulus in the range of 5 to 15 per cent elongation of a typical rubber suitable for use in tension has been found to be 240 lb per sq in.

Problem: Given a sheet of this rubber $^3/_4$ in. thick, 40 in. wide and 20 in. long, what tension will increase the length to 22 in.?

Solution: The elongation is 2 in., which is 10 per cent. The cross-sectional area is $^3/_4 \times 40$ in. = 30 sq in. A 100 per cent elongation requires a tension of 240 lb per sq in., hence, 10 per cent elongation requires a tension of 24 lb per sq in. of the original cross section $\times$ 30 sq in. = 720 lb total tension.

(2) COMPRESSION

Insulating pads of rubber, which have been used for many years under heavy machines and which were used for the mounting of automobile engines prior to the universal adoption of "adhesion mountings," are in reality springs, although they deflect only slightly. For the purpose at hand, rubber is assumed to have no volume compressibility. A slab or column of rubber subjected to a compressive load will, therefore, not deflect if it is fully confined.

Certain general laws of performance have been established and are known to be approximately correct.

A Columns

The deflection of columns of identical rubber compounds carrying equal unit loads and having equal cross sections are directly proportional to their respective heights. The studies, from which this law was derived, were confined to rectangular specimens. For example, column *A* is 12 in. high with a base of 3×6 in; column *B* is 9 in. high, with a base of 3×6 in. If made of identical rubbers, *B* will deflect three fourths as much as *A*, if both carry a load of 10 lb per sq in. This law is approximately true so long as the height is not less than the smaller dimension of the base. Where square bases are used, the law appears to apply down to the cube, below which the specimen is considered to be a slab.

TABLE 1 APPROXIMATE PHYSICAL PROPERTIES OF VARIOUS RUBBER COMPOUNDS

Rubber compound	A-30	B-40	C-50	D-60	E-70
Nominal hardness					
Shore durometer	30	40	50	60	70
Pusey & Jones plastometer	175	145	117	92	70
Specific gravity	1.01	1.06	1.11	1.17	1.24
Tensile strength of original cross section, lb per sq in.	2000	2800	3500	3500	3000
Elongation at rupture, per cent	850	750	700	600	700
Shear modulus, lb per in., per sq in., per in. of thickness	48	65	84	108	166
Average tension modulus for 0 to 10 per cent elongation, lb per sq in.	128	190	240	...	..
Vibration data at 77 F					
Energy loss per cycle, per cent	16.1	18.4	38.9	60.6	77.3
Decrease in amplitude, per cent	8.5	9.6	21.8	37.3	52.4

B Proportional Slabs

Proportional slabs of identical rubber compounds deflect the same percentage of their respective thicknesses under equal unit loads. This enables the approximate deflection of a slab measuring $12 \times 6 \times 1$ in. under a unit load of 50 lb per sq in. to be forecast if the deflection of a $3 \times 1^1/_2 \times {}^1/_4$-in. slab of

Contributed by the Special Research Committee on Mechanical Springs and presented at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, N. Y. Nov. 30 to Dec. 4, 1936.

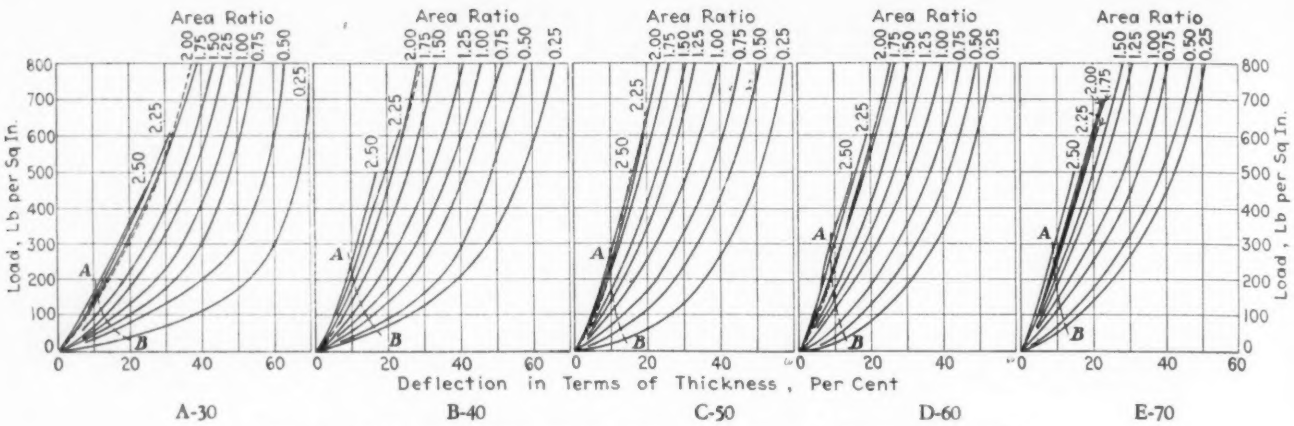

FIG. 2 LOAD-DEFLECTION CURVES FOR FIVE TYPICAL RUBBER COMPOUNDS
(Deflections to the left of the line *A-B* on each set of curves are considered safe practice.)

identical material under the same unit load is known. Obviously, this has serious limitations in its usefulness.

C Equal Area Ratios

The area of one loaded face of a slab is called the "load-bearing area" or "top area." The area of the unconfined edges of a slab, including the walls surrounding unfilled holes, is known as the "bulge area." The load-bearing area of any slab divided by the bulge area is the "area ratio." For example, a slab 2 in. square and 1 in. thick has a load-bearing area of 4 sq in. and a bulge area of 2 in. (length) × 1 in. (thickness) × 4 (sides) = 8 sq in. The area ratio is 4 ÷ 8 = $^1/_2$. A slab of the same thickness, 1 in., but 4 in. square has a load-bearing area of 16 sq in., a bulge area of 4 in. (length) × 1 in. (thickness) × 4 (sides) or 16 sq in., and an area ratio of 16 ÷ 16 = 1. Data on the load-bearing and bulge areas and the area ratio for various sizes of square slabs having a thickness of 1 in. are given in Table 2.

TABLE 2 LOAD-BEARING AND BULGE AREAS AND AREA RATIO FOR SQUARE SLABS 1 IN. THICK AND VARIOUS LENGTHS OF SIDE

Length of side, in.	Load-bearing area, sq in.	Bulge area, sq in.	Area ratio
1	1	1	0.25
2	4	8	0.50
3	9	12	0.75
4	16	16	1.00
5	25	20	1.25
6	36	24	1.50
7	49	28	1.75
8	64	32	2.00
9	81	36	2.25
10	100	40	2.50

Slabs of identical rubber compound having equal area ratios and carrying equal unit loads deflect the same percentage of their respective thicknesses. Load-deflection data for the five typical compounds, whose physical properties are given in Table 1, are presented in Fig. 2. All slabs from which the data were obtained were square. Calculations for deflections of slabs that do not have square load-bearing areas have repeatedly been found to be approximately correct. Discrepancies are apparent, particularly between curves for higher area ratios. These are due to slippage of the pressure faces of the slabs. This slippage might be overcome by bonding the slabs to steel plates, but, since this is frequently not done in practice, the data are presented just as they were obtained. Deflections to the left of the line *A-B*, which are shown for each of these compounds, are considered safe practice.

To use the data, find the area ratio of any slab and the unit loading. Locate both values on the charts, and select the rubber that is best suited to the purpose, keeping in mind all the factors involved.

Problem: Design a compression spring having a 7-in. O.D., a 3-in. I.D., and an approximate free overall height of 5 in. to carry a load of 5000 lb safely.

Solution:

7-in. circle	38.5 sq in. area	21.9 in. circumference
3-in. circle	7.1 sq in. area	9.4 in. circumference
	31.4 sq in. net area	31.3 in. total circumference

5000 lb load ÷ 31.4 sq in. net area = 159 lb per sq in. unit load

Rubber thickness, in.	0.875	0.8125	0.844
Bulge area = total circumference × thickness, sq in.	27.4	25.5	26.5
Area ratio	1.15	1.23	1.19
Deflection for compound C-50			
In terms of thickness (see Fig. 2), per cent	12.0	11.5	11.8
One disk, in.	0.105	0.093	0.0995
Five disks, in.	0.525	0.465	0.497

The thickness of 0.844 in. was chosen as giving a reasonably

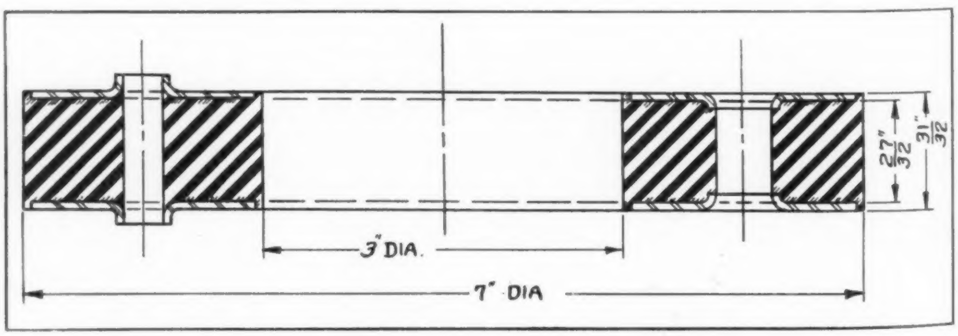

FIG. 3 SLAB USED FOR RUBBER COMPRESSION SPRING

large deflection and being as thin, and therefore as light, as practicable. If the softer compounds, A-30 and B-40, were used, it was thought that the deflections would be excessive. Fig. 3 shows the slab used; the rubber thickness being $^{27}/_{32}$ in. and the overall thickness, $^{31}/_{32}$ in. To maintain proper alignment of the superposed disks, dowels and holes were provided as shown.

Problem: What is the maximum safe deflection under a load of 1070 lb for a slab $4 \times 2^1/_2 \times {}^1/_2$ in. thick (under load) and having one clear hole $1^1/_8$ in. in diameter through it?

Solution: Load-bearing area is $2^1/_2 \times 4 - (\pi/4) \times (1^1/_8)^2 =$ 9.01 sq in.

Assuming a free thickness of $^9/_{16}$ in., the bulge area is $^9/_{16}(13 + 1^1/_8 \times \pi) = 9.3$ sq in. The area ratio is $9.01 \div 9.3 = 0.97$. 1070 lb load ÷ 9.01 sq in. load-bearing area = 130 lb per sq in. unit load

From Fig. 2, the following data are obtained

Compound	E-70	D-60	C-50	B-40
Deflection				
In terms of thickness, per cent...	9.0	10.6	11.6	15.2
Actual, in.	0.0506	0.0596	0.0652	0.0855

The deflection for compound B-40 was considered excessive. Compound C-50 was, therefore, chosen and functioned satisfactorily.

A wide variety of problems present themselves. These require many compromises in calculation and design and, occasionally, laboratory work to determine the answers.

Where rubber surrounds a cylindrical shaft and is pushed toward it, the projected area is arbitrarily, but nevertheless correctly, calculated as the length of rubber contact, parallel to the axis, multiplied by 70 per cent of the shaft diameter.

(3) SHEAR

In general, rubber stressed in compression will carry heavier loads with smaller deflections than rubber stressed in shear. Since many cases of vibration absorption require large deflections, rubber in shear is being used extensively.

What is known as a "sandwich" can be made by bonding or "adhering" plates of steel or certain other metals to both sides of a rubber slab. If one of these plates is now held in a fixed vertical position and a load hung on the other plate, the rubber slab will allow this loaded plate to move downward or deflect a certain distance. The relative movement between these two plates resembles that of the blades in a pair of shears. The rubber slab is then said to be distorted, or deflected, or stressed "in shear," and this arrangement of steel plates and the rubber slab is called a "shear sandwich" or a shear mounting.

When properly used, these sandwiches or mountings, in the vast majority of cases, provide the best means known for absorbing vibration because

(1) Large deflections are permitted.

(2) No slippage occurs, thus eliminating all abrasion and wear.

(3) Noise is not transmitted, as is done by steel and wooden mountings.

(4) By proper arrangement, a mechanism can be cushioned vertically, while it is restrained horizontally.

(5) Vibration dies out rapidly after the exciting impulses stop.

(6) Where properly arranged, the deflection is not terminated by a metal-to-metal stop which would cause shock and attendant high stress in metal parts.

(7) Deflection is according to Hooke's law; that is, proportional to the load.

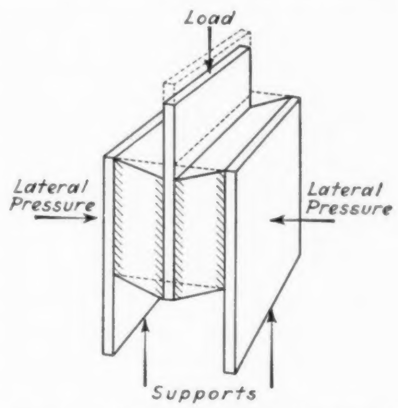

FIG. 5 A "SHEAR SANDWICH" HAVING TWO WALLS OF RUBBER THAT ARE STRESSED IN SHEAR

(The two outer plates are subjected to a limited lateral pressure, which does not, however, stiffen the action in shear.)

In the elementary shear sandwich, if the rubber dimensions are made $1 \times 1 \times 1$ and the applied load is divided by the deflection, the quotient is the "rate per inch" as a spring. Since both area and thickness are unity, this figure is also the shear modulus of the rubber compound. Stiffness varies directly as the area and inversely as the thickness, hence $r = MA/t$, where A is the area, t is the thickness, M is the shear modulus, and r is the rate per inch of any shear sandwich.

Adhesion items are often pulled apart in testing machines. The mountings at the left and right of Fig. 4 have been subjected to this treatment. The tenacity of the rubber has caused the inner channel-shaped metal, which originally had the shape shown in the middle view, to turn inside out. Manufacturers guarantee a bond strength of between 200 and 250 lb per sq in. under this test. In actual practice, however, the bond between the rubber and the metal is customarily stressed at only 25 to 50 lb per sq in. Good practice requires the thickness of a shear sandwich to be not more than one quarter of the smaller of the other two dimensions. Placing a shear sandwich under a lateral pressure of between 50 and 100 lb

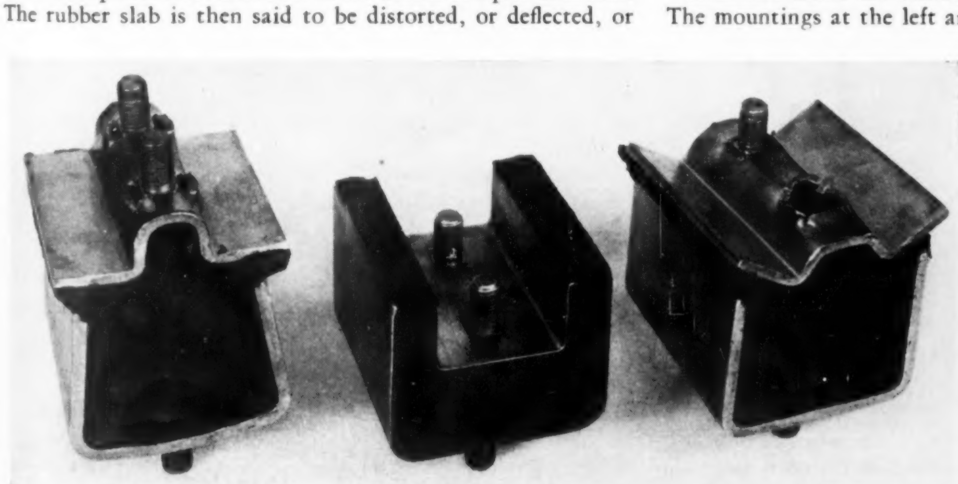

FIG. 4 ADHESION MOUNTINGS THAT HAVE BEEN PULLED APART IN A TESTING MACHINE

(The original shape of the mounting is shown in the middle, while the other views show the mounting after the test. The tenacity of the rubber caused the inner metal channel to turn inside out.)

per sq in., as indicated in Fig. 5, is also good practice. This lateral pressure does not measurably affect the stiffness in shear.

In general, the rubber thickness should be kept down to 2 in. This requirement is desirable but not essential. Hence, making rubber springs with two or more sandwiches bolted together in series is frequently advisable. This arrangement is called a "stack," and pairs of stacks can be opposed, similarly to the two rubber walls of the sandwich illustrated in Fig. 5.

Problem: Design a rubber shear spring that will deflect approximately $3^1/_2$ in. under a load of 20,000 lb.

Solution:

20,000 lb load ÷ 3.5 = 5720 lb per in. = r
20,000 lb load ÷ 25 lb per sq in. bond stress = 800 sq in. required bond area = A

Table 1 of approximate physical properties gives the shear modulus of compound A-30 as 48. This compound should be used on account of the large deflection that can be secured with it, thus resulting in less total weight and cost for the rubber spring. Substituting the various values in the formula $r = MA/t$ gives 5720 lb per in. = 48 × 800 lb per sq in. ÷ t, which, when solved, gives a thickness of 6.72 in.

A sandwich 6.72 in. thick and having 800 sq in. of bond area would be unwieldy. Hence, it may be made either in three units each 2.24 in. thick or in four units each 1.68 in. thick. If arranged in opposed stacks, the bond area of each will be 400 sq in., and the size might then be 40 × 10 in., 15 × 26.7 in. or some other practicable dimensions whose product is 400. Since shear sandwiches are usually subjected to lateral compression, calculations must be made to determine the decrease in rubber thickness which will bring about the desired unit pressure. Where the stiffness in compression is specified as well as the stiffness in shear, considerable cut-and-try calculating will sometimes be necessary.

SHEAR SPRINGS AND STRUCTURAL SPONGE RUBBER

Shear springs of many sizes are now in use, the most extensive being for the mounting of engines in American motor cars. As designing engineers, plant superintendents, and maintenance men become more familiar with the advantages and safety of rubber mountings, their use will undoubtedly extend into more and more industries.

That resilient rubber mountings must be proportioned properly to function efficiently is obvious to engineers familiar with vibration-absorption problems. An improperly timed resilient mounting may result in far worse vibration than if no mounting were used.

Fig. 6 illustrates a typical rubber spring designed for large deflections in the shear plane and for much smaller deflections at right angles thereto. Figs. 7 and 8 show a type of rubber spring or mounting arranged to support heavy machines resiliently. An application of this mounting has been made in a yacht, where one mounting is arranged transversely to withstand propeller thrust. An application of another type of rubber-spring mounting under a motor-generator set, where it prevents vibration from releasing a circuit breaker is illustrated in Fig. 9. Fig. 10 shows a type of shear spring suitable for some applications, being adapted to surround a cylindrical structural member.

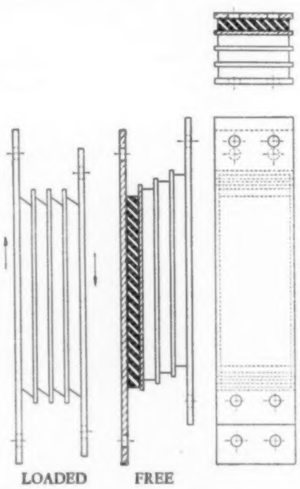

FIG. 6 RUBBER SPRING DESIGNED FOR LARGE DEFLECTIONS IN THE SHEAR PLANE AND FOR MUCH SMALLER DEFLECTIONS AT RIGHT ANGLES THERETO

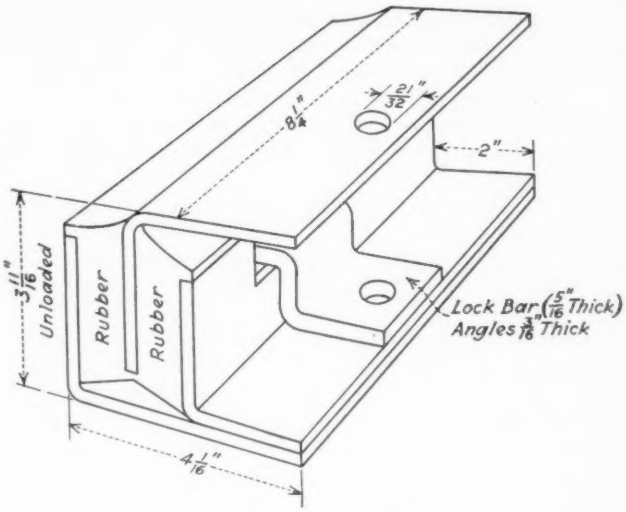

FIG. 7 SHEAR MOUNTING

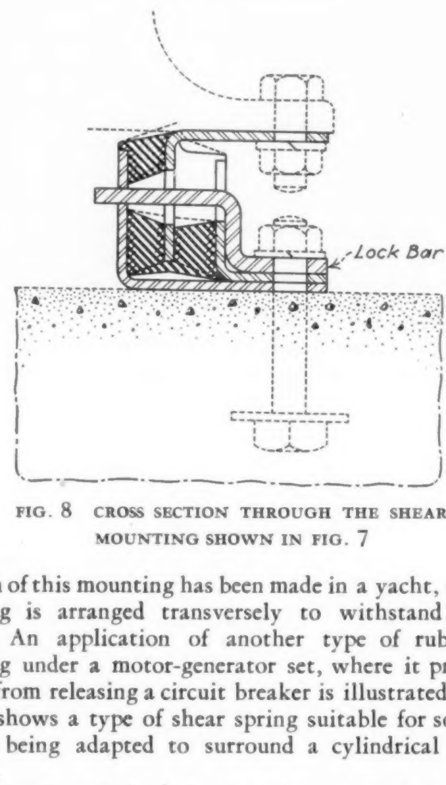

FIG. 8 CROSS SECTION THROUGH THE SHEAR MOUNTING SHOWN IN FIG. 7

Attention is called to the fact that none of these rubber-spring mountings can fail completely under the most extreme abuse, without first destroying some steel parts. Should the rubber fail, due to excessive heat or prolonged exposure to oil, contact between two relatively vibrating metal parts would occasion a clatter, which would draw the attention to this condition.

Engineers and architects should know of the possibilities of structural sponge rubber for use as springs of limited deflection and load-carrying capacity. This material is compressible and was first used in the new physics building at the Massachusetts Institute of Technology in an installation planned by Dr. Roscoe Gerke. A slab of the material 1 in. thick supports an 8000-lb planing machine and its foundation which is a slab of reinforced concrete approximately 20 × 8 ft × 19 in. thick. The principle of this application is outlined in Fig. 11. The

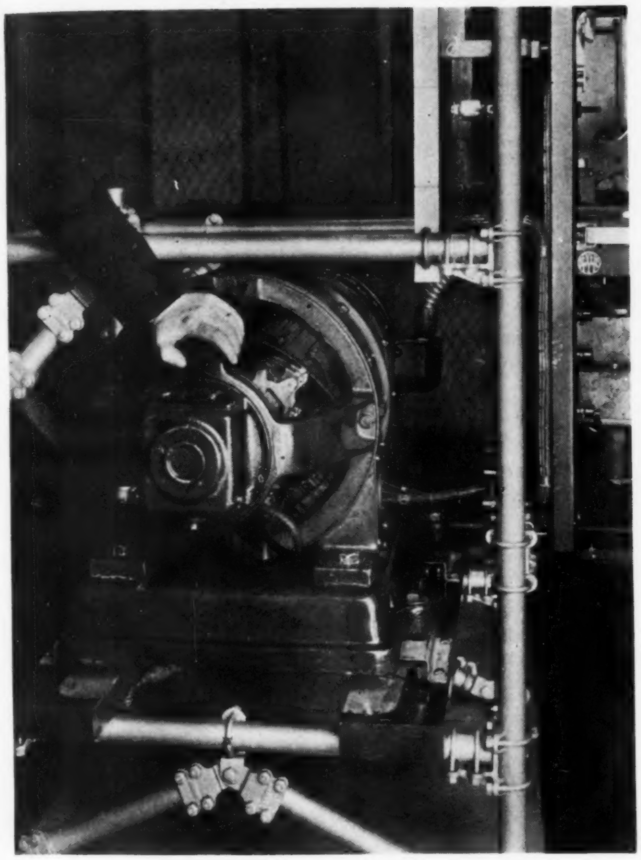

FIG. 9 RUBBER SPRINGS APPLIED TO ELECTRIC-MOTOR MOUNTING

unit load is approximately $2^1/_2$ lb per sq in. and the static deflection $^1/_{10}$ in.

The installation was made five years ago, and since that time, no measurable permanent set has been discovered. Use of cheap, ordinary sponge rubber for such an installation may require early and expensive replacement.

GENERAL COMMENTS

Rubber hardens slightly at low temperatures. For example, one compound that has a durometer hardness of 30 at room temperature shows a hardness of 37 at —50 F. Another compound tested 50 at room temperature and 54 at —20 F. Rubber is attacked by oil and should be protected from it. Progress has been made in this direction by coating with flexible lacquer. Steel plates of shear springs can be treated to resist rust, but, as yet, either of these protections is not considered thoroughly effective. Rubber springs, for best results, should not be subjected to temperatures higher than 120 to 150 F, as high temperatures mean low carrying capacities. Wherever possible, rubber should be protected from sunlight and ozone, both of which promote surface checking.

Rubber springs, to be effective, must not be hampered by bolts or other metal parts providing metallic contact between the two units that should be insulated. That construction can defeat the object of a noise-insulating mounting.

The question frequently arises, "What is the life of rubber springs?" Many of the original "adhesion mountings" introduced into the automobile industry are still functioning satisfactorily after 8 or 9 years' use. Therefore, a useful life of from 4 to 8 years for rubber springs, when used under favorable conditions, can safely be assumed.

Rubber can be successfully bonded to almost every metal, although S.A.E. 1010 hot-rolled steel is generally used for shear springs on account of the cost. Where exposure to weather is a serious factor, the metal members should be brass or bronze. Adhesion to many metals does not fit in with present-day commercial practice.

In designing rubber springs that incorporate adhered metal pieces, the fact that these metal parts must enter the cavity in a steel mold, must be borne in mind, and, if they do not fit the cavity, no production is possible. Therefore, the allowable variations in dimensions must be allowed for and definitely specified so that molds can be made accordingly.

That two different rubber compounds having the same durometer hardness may perform differently under stress is, perhaps, unfortunate. The data given herein refer specifically to certain "structural-rubber" compounds of United States Rubber Products, Inc.

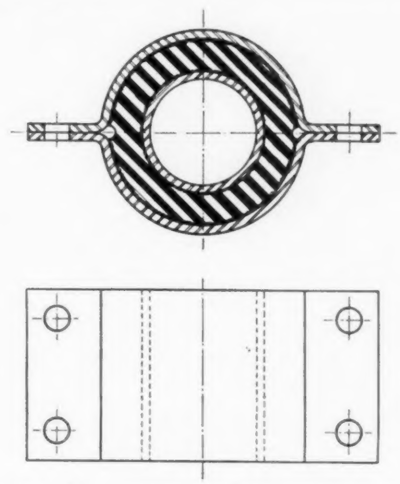

FIG. 10 RUBBER COLLAR DESIGNED TO SURROUND A COLUMN

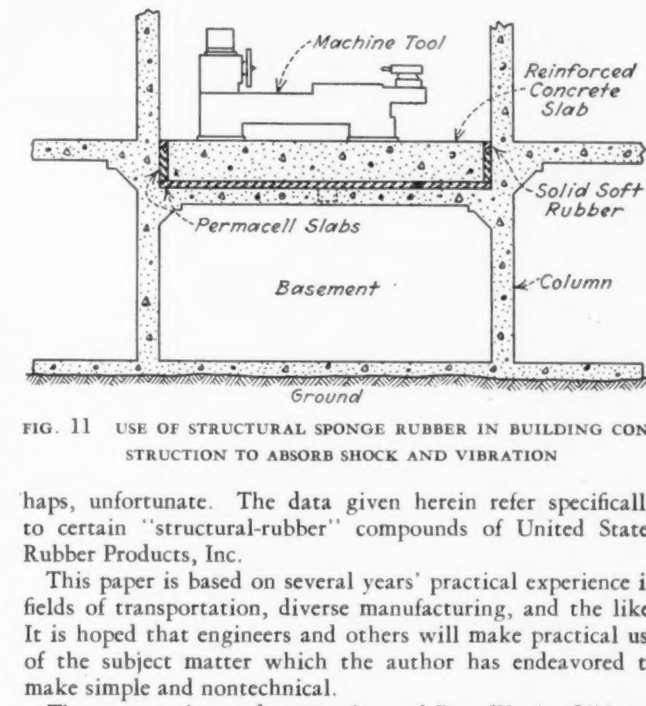

FIG. 11 USE OF STRUCTURAL SPONGE RUBBER IN BUILDING CONSTRUCTION TO ABSORB SHOCK AND VIBRATION

This paper is based on several years' practical experience in fields of transportation, diverse manufacturing, and the like. It is hoped that engineers and others will make practical use of the subject matter which the author has endeavored to make simple and nontechnical.

The cooperation and suggestions of Drs. W. A. Gibbons, Roscoe Gerke, S. M. Cadwell, R. A. Merrill, and C. F. Hirshfeld; and Messrs. J. D. Morron, C. M. Sloman, Emil Piron, E. W. Hull, and A. N. Benson, and others are acknowledged and appreciated.

EMPLOYMENT *of the* ENGINEER

TWO SUMMARY reports based on analyses made by the United States Bureau of Labor Statistics of returns from 52,589 professional engineers have already appeared.[1] The present article, which shows the kinds of employment engaged in at specific periods, is based on the third report.[2]

The study on which the reports are based was undertaken in May, 1935, at the request of the American Engineering Council. A questionnaire, mailed to 173,151 engineers, directed the engineer replying to it to check his employment status for each of the three years ending Dec. 31, 1929, 1932, and 1934 against only one of fourteen items. These 14 categories were reduced to 8 for purposes of reporting the results, as follows: Private firm, independent consultant, teaching, federal, state and county, municipal, and other public authority, nonengineering employment, and total unemployment, which included also work relief and direct relief.

Because the complete summary report is readily available only the general findings will be presented here.

Over the five-year period ending December, 1934, the number of persons in the engineering profession increased by 25.3 per cent. This rate of increase was much in excess of available engineering employment opportunities.

The growth among the several professional classes over the period 1930–1934 ranged from 17.6 per cent for mining and metallurgical to 62.5 per cent in the case of chemical and ceramic engineers; for mechanical and industrial engineering, it was 25.5 per cent.

The lack of opportunities for engineering employment differed markedly among the professional classes. Thus, over the five-year period, and for the profession as a whole, private engineering employment declined by 8.2 per cent, but it increased by more than a third for chemical and ceramic engineers. There was little increase or decrease for electrical, mining and metallurgical, and mechanical and industrial engineers; the percentage was 1.9 for mechanical and industrial engineers. In the case of the civil engineers, however, there was a decrease of about one third in private engineering employment.

All professional classes participated in the increases in employment of engineers by public authorities. The civil engineers were most affected. The proportion of this group employed by public authorities increased from 40.0 per cent in 1929 to 48.5 in 1934. For mechanical and industrial engineers the increase was from 5.9 to 7.6 per cent.

The fact that available engineering opportunities did not keep pace with the increase in the number of men trained to enter the profession brought about changes in the proportions of those who were unemployed, or in nonengineering work.

In 1929 private engineering furnished by far the greatest employment for engineers. For civil engineers this covered 54.3 per cent. There was a range of from 80.6 to 87.3 per cent among the four remaining professional classes, the higher percentage being for mechanical and industrial engineers. By December, 1932, private engineering among civil engineers had dropped to 37.6 per cent and by December, 1934, to 31.8 per cent. There was also a continuous decline in this type of employment among electrical engineers; only 63.1 per cent reporting such employment in December, 1934. For mechanical and industrial engineers this percentage was 70.8. There was only a slight improvement over 1932 for the remaining professional classes. In 1934 these three averaged 69.1 per cent.

Nonengineering employment increased sharply from 1929 to 1932 and in equal measure for all professional classes, absorbing many more engineers than did public engineering, in which employment also increased. But despite the fact that the proportions of all engineers in nonengineering employment rose from 6.3 per cent in 1929 to 12.0 per cent in 1932 (6.1 to 12.4 per cent for mechanical and industrial engineers), there was an even larger increase in unemployment. This situation was common to all professional classes.

Between December, 1932, and December, 1934, there were further increases in nonengineering employment for all professional classes. The increases were not so great as between 1929 and 1932. Unemployment declined for all professional classes, except for civil engineers. This decline for mechanical and industrial engineers was from 10.7 to 7.3 per cent.

The sharpest increases in public engineering employment occurred in the period 1932–1934.

Of all engineers who reported as being professionally active prior to 1930, only 46.2 per cent were in the employ of private firms in 1934; in 1929, 62.2 per cent were so engaged. Federal government employment provided for 10.1 per cent in December, 1934; in 1929, this field gave employment to only 5.3 per cent.

Over the period 1930–1934 there was a remarkable stability in the number of engineers classified as independent consultants, and those engineers engaged in the teaching of engineering subjects. This was also the case for those in the employ of state and county, and municipal and other public authorities, especially if considered together.

The net new private firm employment that developed between 1930 and 1934 was secured by newcomers who entered the profession in this period. In absolute number, 5002, or 16 per cent of the engineers active in the profession before 1930 suffered loss of engineering employment. Some 3112, or 18 per cent, of the new entrants found engineering work with private firms. The increase in public engineering employment was shared by both older and younger engineers.

Over the five-year period the younger engineers also had a decided advantage in securing nonengineering employment. Thus, while 1233 older engineers were so engaged, 2323 of the younger were able to find work of a nonengineering nature. The ratio of those who secured nonengineering work decreased progressively with age. Thus, 15 per cent of the displaced engineers who were over 52 years old in 1934 secured nonengineering work. The remainder were unemployed. Among those who were 28 to 32 years of age, 52 per cent secured nonengineering employment. But even the ratio of 52 for engineers entering the profession in 1925–1929 was very much less than either of those for the 1930–1932 and the 1933–1934 engineers. Thus, in the case of the former this was 78 and for the latter 69.

This analysis indicates that between 1930 and 1934 there was a substantial net loss of employment by the engineers active before 1930, and a considerable absorption in employment of newcomers to the profession.

[1] "Education of the Engineer," MECHANICAL ENGINEERING, August, 1936, pp. 505–509. "Educational Qualifications in the Engineering Profession," *Monthly Labor Review*, June, 1936, pp. 1528–1542; also reprinted as B.L.S., Serial No. R. 400.
"Unemployment of the Engineer," MECHANICAL ENGINEERING, March, 1937, pp. 178–181. "Unemployment in the Engineering Profession," prepared by A. F. Hinrichs, chief economist, and A. Fraser, Jr., Division of Wages, Hours, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, January, 1937, pp. 37–59; also reprinted as B.L.S. Serial No. R. 497.

[2] "Employment in the Engineering Profession, 1929–1934," prepared by Andrew Fraser, Jr., Division of Wages, Hours, and Working Conditions, Bureau of Labor Statistics, *Monthly Labor Review*, April, 1937.

ENGINEERING EDUCATION

A SPECIAL luncheon conference on engineering education was held in connection with the 1936 Annual Meeting of the A.S.M.E. at Midston House on Dec. 3. Papers dealing with three phases of this important subject were presented by W. H. Carrier, N. E. Funk, and H. O. Croft, and are printed, substantially in full, below. Each author brought numerous points of importance to educators and engineers. The more outstanding ones follow.

Emphasis was laid by Mr. Carrier on the fact that engineering education, in most colleges, places a premium upon memorizing instead of stimulating independent thinking and that it is deductive rather than inductive. Futility of repeating the teaching of the same principles in different engineering courses where the student did not grasp the relation was stressed by Mr. Funk, who also drew upon his own experience to show how the same principles when taught differently in separate courses remained as separate ideas for some time after graduation. Professor Croft commented upon the growing tendency to lower the requirements for graduation from high school below the minimum that would serve as a foundation for an engineer's education and proposed the formation of a national committee to study this problem thoroughly and prepare a high-school curriculum that was planned more particularly for those students who intended to enter professional schools.

PRINCIPLES *Versus* CURRICULUM *in* MEMORIZING FACTS *and* THEORIES

By W. H. CARRIER

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AS SHOWN by its results, present practice in engineering education seems to be faulty in several respects. It appears to be designed almost wholly for the students who acquire all their knowledge from books or from their teachers' efforts, while it neglects the smaller but more important group who can go beyond the boundaries of existing knowledge.

The present system, instead of stimulating the creative imagination so necessary for the successful engineer, seems to discourage or dull it. It allows students to accept facts blindly instead of training them to understand and to reason for themselves. In spite of this training, engineers with exceptional ability and strength of character do develop the ability to think independently and advance beyond the boundaries of existing knowledge by retaining and developing their own creative imagination.

We find engineering students who have a superficial knowledge of many things with minds loaded with partly digested facts but generally with a very poor grounding in the basic physical laws on which engineering is founded or a thorough understanding of them. The chief reason for the state of affairs we find in our engineering schools is that engineering knowledge and its application have multiplied to such an extent that to begin to cover the field adequately, by the time-honored methods with segregated subjects, in a four-year course is impossible. The schools have attempted to meet the demands of the public, of employers of engineers, and of faculty members with some particular bent. The result is a greatly overcrowded curriculum with far too much attention to specific applications of engineering, too advanced specialization in various individual subjects, and, more particularly, *insufficient coordination* of allied subjects. The main purpose of an engineering education, the understanding of principles, and the use of mental tools of the profession, is thus overlooked and defeated.

THINKING A LOST ART AMONG ENGINEERING STUDENTS

The student is expected to learn more and more in a given time, and the courses must be made "easy" so that he can accomplish the work laid out in the curriculum. To obtain high or even passing marks, he must rely on memory, as this is the easiest and most primitive process. He cannot be trained to think nor would he have time if he tried. He becomes the skin of a sausage which is to be stuffed with meat, and many of our educational products are just about that. They have not been trained to think nor have they acquired confidence in their own mental processes outside of their ability to memorize and to gather facts from the printed page. Thinking, to their minds, is an outmoded process; and they dislike it. They want to be given formulas in which their data can be placed, and by which the required results can be mechanically computed. They want to be slide rules. They think this is engineering. The surprising thing about much of our technical education is that the product is so good in spite of the education rather than because of it.

Another failure of the engineering schools from the employer's standpoint is that he finds difficulty in selecting a man on the basis of his standing in college. The student with apparently the very best standing may be merely a memory machine and, therefore, of little value to the employer subsequently. Wastage in hiring engineers, especially for technical positions, is great.

So far in this discussion, I have, perhaps, been overcritical. I do appreciate the great amount of valuable teaching that is done, but I think that, in many cases, our objectives are wrong. Improper emphasis is placed on the things that are of the least value to the engineer at the expense of those that are vitally important. Perhaps one of the reasons for my rather extreme attitude in this matter of engineering education is my own personal experience in three phases, precollege, college, and postcollege education. This experience, together with subsequent dealings with graduates of many of our engineering institutions, is the basis of my criticism, and, from it I hope to make constructive suggestions. For this reason, I may be pardoned if I recite some incidents that are based on my personal experience.

In my own education, I feel that I was extremely fortunate in not having it regimented in my early years. I went to a two-room district school; then, to a small-town high school.

I became interested in mechanics and learned it largely through the study of farm machinery. I worked out the mathematical principles of the lever, the pulley, the wedge, and elementary hydraulics without the use of a text, experimentally and by rationalization. I found an old high-school textbook on physics which had once belonged to an uncle. I read it with interest and understanding because of my personal experience. I never studied the subject in high school, but passed the state examination with the highest possible mark, because I thoroughly understood the subject.

In mathematics, until I went to college, I never relied upon classroom explanation or the text but solved the problems myself. This was true from my first contact with fractions in arithmetic, when my mother taught me that I could learn things at first hand, and from there on through geometry. By this method, I acquired a power and the confidence in that power, which I certainly could not have gained otherwise and which I would not have obtained in a modern highly regimented educational system. Therefore, I feel such a system is unfortunate and should be changed.

At college, on account of the pressure of curricular requirements, I had to accept many things as facts which I learned to understand thoroughly only after graduation. I felt then, and still feel, that the latter was not sound education and that I would have been greatly handicapped in after development, except for my early unregimented experience. After graduation, I followed methods of self-education that I had formed prior to my college years and not those obtained in college. I studied things at first hand and rationalized them independently, rather than studying books, and used books only to test my own conclusions.

COLLEGE-ENTRANCE REQUIREMENTS SHOULD BE CHANGED

One of my greatest objections to present college practice lies in the requirements of admission. Our high schools and preparatory schools can hardly be criticized for their methods of teaching, since the requirements of the college cause them to teach as they do. Let the college change its requirements and type of entrance examination. Then the high schools and preparatory schools will, of necessity, follow and gradually come to give the type of education suggested in this paper as having the most value.

Engineering colleges should require, for entrance, not only the usual mathematics but also elementary high-school physics as well, because in these subjects, ability for independent thinking and also the natural aptitude for pursuing engineering studies can best be tested. To the present requirements should be added an examination in what was formerly called "mental arithmetic," in which no figure could be placed upon a paper and would involve problems of the simplest type but would require the student to visualize the elements of his problem to solve it correctly. This method of teaching has almost wholly passed out in our schools and colleges, but it is the key to the training and testing of ability to think. Passing marks for such an examination should be as high as 80 per cent instead of the usual 60. A student is either able to think correctly or else he is not. Tests for accuracy and speed, while important, should be separate and entirely secondary, and the passing mark for these could be considerably lower. The whole test should be, not one requiring quantity of knowlege, but clear thinking and visualizing, as distinguished from abstract deduction. In all mathematics as well as in physics, a primary and a secondary test should be given. For the first, the type of question employed should show conclusively whether the student thoroughly understands what he is doing and a relatively high mark should be given for such understanding. These questions should involve only the simplest numerical calculations but should require mental vision and analysis. The secondary examination would test for accuracy and acquired facility, but this examination should not require so high a passing mark.

I realize that, immediately upon such a change of entrance policy, a great outcry would arise that the examinations were "tricky and unfair." Students who have not been required to think do not like to. Such a method of selection, however, would secure better teaching in secondary schools with proper emphasis on mental training, rather than on extent of subject matter, for the secondary schools have many able teachers who would like to give this kind of instruction but are unable on account of quantitative requirements. It would also insure a selection of material for engineering schools with which something could be done later. If such selection were not made, carrying out the proposed changes in engineering education and compensating in college for the inadequacies and undoing the harm of faulty precollege education would be extremely difficult if not impossible. This method of selection would also keep out the mentally unfit. Engineering schools have no business to take such a large percentage of young men and "bust" them out in their freshmen year. They have no business going on with the farce of training young men who will never make engineers. Such procedure is a great waste of time and money both for the school and the student.

INDUCTIVE VERSUS DEDUCTIVE INSTRUCTION

The deductive method of instruction is standard in most of our institutions. It has many advantages; it presents a study in the orderly way; is comprehensive and correlates all phases of the subject; is easy to learn; and, above all, is easy to administer. The natural method, by which one approaches the analysis of a subject outside of books, however, is the inductive method. First, the student observes phenomena, then, he exercises his perception, studies and analyzes the relationships involved, and ultimately draws his conclusions. He goes from the concrete to the abstract, not from the abstract to the concrete. His is the natural method, the one that develops mental power and correct approach to the unknown. Hence, it is the method of progress. It begins in the laboratory, either literally or figuratively, and ends with the deduction of a principle, which is mathematically expressed where possible. In this method of study, the teacher should be merely a guide or umpire, if its purpose is to be attained, and no outside assistance should be given or secured. If correctly applied, it is much more difficult for both teacher and pupil, and, to be effective, it must cover relatively little ground in a given time. Often, in improper hands, it becomes a farce, especially if hurried. It is too slow a process to be successful in covering all the ground that is necessary in an engineering course, and, for this reason, it should be used in a preliminary inductive study of the essential elements of the subject followed by a thorough deductive presentation where ground is covered thoroughly and understandingly, rather than extensively as at present.

In every case, two separate and distinct types of test or examination should be given, as in the entrance requirements. The first should test the thoroughness of understanding, that is, the quality of knowledge, especially in the essential elements of the subject, and the second, the extent of knowledge and facility in numerical application. The former should require a much higher percentage for passing than the latter. Again I would suggest 80 and 60. Capability in one type of examination should not be substituted for that in another. Pupils should not be permitted to become parrots or allowed to

acquire an inferiority complex by dealing with things that they do not thoroughly understand. If they cannot gain a thorough understanding of a subject, they should not study it. Half knowledge is not only useless but also dangerous and defeats the very purposes of education. This should be the first principle in all instruction of engineers. Students should be encouraged to make thoroughness of understanding an ideal—a habit of mind that will stand them in good stead in future development, after graduation. The great importance of a proper measure of the inductive method is that the student learns how to get knowledge from things observed rather than being wholly dependent upon the printed page. Personally, I have had very little use for texts or engineering articles except for purposes of information and reference after graduation. One must, perforce, do some technical reading to keep up with progress in his field, but primarily his own progress has to be made through personal observations and deductions. This is true of anyone who has ever accomplished anything in the way of engineering advancement. Hence, the importance of a type of engineering education that will put this method to the forefront and make it a habit is apparent.

TECHNICAL COURSES SHOULD DEVELOP CREATIVE IMAGINATION

This method of self-instruction and inductive approach accounts for the achievements of James Watt, Edison, Ford, Wright brothers, Kettering, and a host of others. Lack of the knowledge given in a formal education sometimes seems to put men on their own resources, which is more important than the learning of many facts through a formal technical education. While not undervaluing the broadening effect of a survey of the mathematical and scientific fields on which sound engineering is based nor the importance of facility in the use of engineering tools and methods, the prime objective of our technical courses should be to encourage and develop creative imagination and mental self-reliance in their students. This our technical schools can do. But to accomplish so vital an aim as this requires more than a change of curriculum. It requires recognition by teachers of engineering of its paramount importance. On the part of some of them, it requires complete change of outlook and an overhauling of their methods. Too many teachers of engineering are mathematical and scientific formulists rather than engineers. Many unconsciously teach as to future teachers rather than as to future engineers.

In many of our engineering schools, the tendency to make our education more deductive rather than inductive; more algebraic rather than geometric; more formal, more scholastic, and more complicated rather than simplified, unified, and practical seems to be increasing. The engineering teacher should be either a scientist with a strong natural mechanical bent that is backed by engineering experience or an engineer who has added to his engineering experience a truly scientific education. Above all, he must ever keep the true purpose of engineering education to the forefront.

Our only hope for a real workable improvement in engineering education lies, first of all, in a realization of the inherent defects of our present system by faculty, alumni, and employers in industry. A concerted agreement among educational institutions on a plan for gradually overhauling present admission requirements and curricula is necessary if the desired ends are to be accomplished.

Many educators in our engineering colleges realize the need of this, but they are powerless to accomplish their ends, owing to the practical difficulties in the way, where present curricula are generally in force. Nor can one college stand alone and set an example to the rest, although any college and any teacher with the right ideals in mind can improve its methods. Perhaps, the demand and aid can best come through some concerted action by an association of employers, who will demand, from the schools, the kind of instruction that many educators desire the privilege of giving.

APPLYING SCIENCE *and* ENGINEERING *to* EDUCATION

By N. E. FUNK

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THROUGHOUT my entire business life, I have dealt primarily with facts and, therefore, feel somewhat out of place in discussing a situation in which, to a large extent, I am dealing with second-hand information or am basing my discussion upon considerations that may be antedated. I can only assume that my contact with recent graduates is typical, as is their reaction to various discussions, which seems to indicate that, in the main, while a tremendous increase in the knowledge available has occurred and many changes and additions have been made in the curriculum, the college or university student does not have his various studies properly correlated in his own mind.

Intelligent discussion of any subject must be based on certain specific premises. In this particular situation, it must be based fundamentally upon the objective of an engineering education. While objectives may be as numerous as the different minds considering the problem, an unbiased analysis would classify them into two main divisions: (*a*) training the student so that he will make a better citizen and neighbor and (*b*) furnishing him, to the greatest extent possible, with the basic tools by which he is enabled to follow the occupation that he has chosen.

Four years is a very short time in which to prepare a student properly for future activities, and, for this reason, his studies must be circumscribed very materially. The time available should be devoted primarily to the objectives sought and not wasted on duplication of effort or in pursuing those lines of endeavor that have little or no relation to these objectives. Valuable time is lost because of needless repetition of various subjects, particularly those relating to physics and engineering which, while probably intended to impress the students' minds by reiteration with the basic principles underlying all scientific endeavor, nevertheless are taught in such an uncorrelated manner that the relation between the various courses is so vague and disconnected in the student's mind that he does not obtain the advantage from this repetition that he should.

Many mathematical subjects are taught purely as mental exercises, and their practical application is left to other unrelated courses. Possibly, a large majority of engineering students are required to delve into the realms of higher mathematics beyond any usefulness to them. Partial differential equations unquestionably is a very stimulating mental exercise, but its real value to the engineering student outside of his course in mathematics is very doubtful. This statement

may draw considerable fire from educators, particularly when one delves into the field of electronics, but less than 10 per cent of the engineering graduates of any university fundamentally understand partial differential equations, and are even further at loss in making any practical application of them. Hence, this course, as taught, really is a memory course for the student while he is taking mathematics, rather than one to train him in thinking. The method of teaching partial differential equations might be changed so as to develop his thinking powers, but my contact with recent graduates indicates that their success in passing this subject was achieved by the art of memory alone.

Chemistry should be given to all engineering students. However, a proper appreciation of its relation to all their future endeavors should be instilled in them, so that they will have some comprehension of what they are doing, rather than taking chemistry because passing it is one of the requirements for graduation.

APPLICATION OF SCIENTIFIC THOUGHT SHOULD BE CORRELATED

Specific considerations that are made in application of the scientific thought to one branch of engineering are sometimes entirely eliminated from parallel branches, even though they may be as closely allied to these subjects as to the one in which they were taught. To illustrate this, I wish to give a personal example. When I was in college, we had a course in electric street-railway engineering in which the effect of load factor was discussed at some length. When, however, transformer design was discussed, calculus was used to show that the maximum efficiency of a transformer at a given load was obtained when the iron and copper losses were equal.

After graduation, I took the apprenticeship course of the Westinghouse Electric & Mfg. Co. Once a week, the apprentices were given a talk by one of the department heads of the company, and one of the topics shortly after my arrival at Pittsburgh was distribution transformers. In this discussion, the transformer designer indicated relations between iron and copper losses that were at great variance with the rule of equality. Following the meeting, I talked with the designer and asked him why the relations he gave deviated so much from the demonstration that had been made to me at college. Then, for the first time, he pointed out to me the effect of load factor on the most economic design of this type of apparatus. Perhaps, I should have carried the idea of load factor from the railway course into the course on transformer design, but I did not, and I doubt whether any other member of the class did, for the simple reason that instruction is confined to a specific textbook which, in most cases, deals with the apparatus as an individual element and not with its application.

Load tests on different types of apparatus, I distinctly recall, were made over a wide range of load, but the primary reason was to determine the shape of the performance curves of the apparatus without considering the relation between their shape and the performance of the apparatus. In electrical-machinery design, the question of designing for capacity and economy at full load was made a paramount consideration without any consideration of the most economic design or even the factors that should be considered in this design.

Probably, these shortcomings have been corrected in the intervening years. However, they are only used to illustrate an idea, and even more serious ones possibly are still in existence, for different college catalogs indicate that physics is still taught to engineers by physicists, with their general disregard for practical application. This being the case, they undoubtedly still use the physicists' units and procedures, and, probably, no serious effort is made to correlate these in the students' minds with the units and procedures that he must use later in his engineering courses and professional work following graduation.

CURRICULA SHOULD BE CHANGED TO GIVE MAXIMUM CORRELATION

The engineering student must be given as broad an education as possible, and, to attain this end, he cannot be confined specifically to a single type of reasoning, but the university curriculum should be planned so that the maximum correlation between the various subjects, both in the subject matter and in method of teaching, is made. The vast majority of students would take far greater interest and be benefited more in all the courses presented, if the relationship between that subject matter and the division of engineering endeavor that they are desiring to make their lifework were demonstrated in such a manner that they could see it clearly.

This discussion has been very general and has laid down no definite plans of procedure, but I have tried merely to indicate that the problem of engineering education should be attacked the same as any scientific or engineering problem so that the resulting product is not a heterogeneous mass of parts, each designed and constructed by an individual artisan, but rather a smoothly working machine in which all parts function cooperatively and thus result in a product that will give satisfaction to the user.

ENCOURAGING RESEARCH IN ENGINEERING EDUCATION

By H. O. CROFT

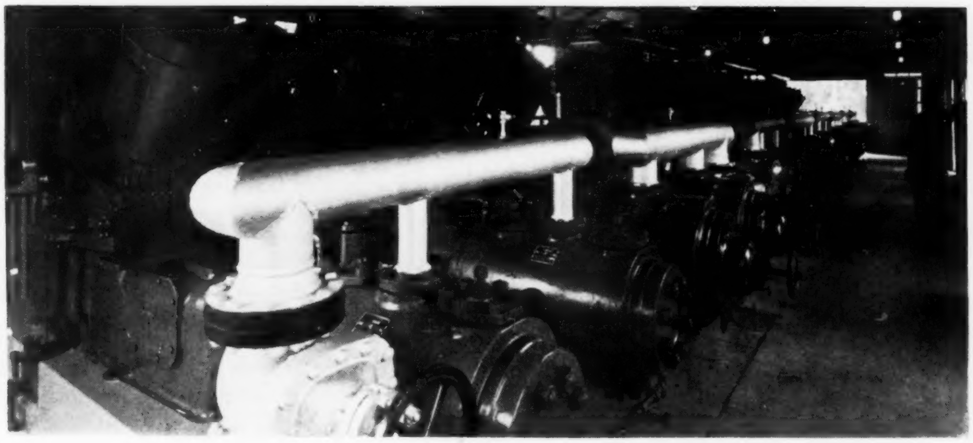
UNIVERSITY OF IOWA, IOWA CITY, IOWA

NO ATTEMPT will be made to sound all the questionable and uncharted depths of engineering education where research should be encouraged but rather to present only one timely and important question. This is submitted to encourage discussion and perhaps, by so doing, indirectly to encourage research in the problems it suggests, with the hope that some overt action may be taken in the future.

This question concerns the high-school training of engineers and makes two facts apparent. First, all college instructors of engineering having contact with entering students are practically unanimous in the opinion that the high-school graduate is poorly prepared for college both in intellectual background and in habits of study. Second, high-school administrators continually seem to be lowering the intellectual hurdles of their institutions. For example, a movement is now under way to remove mathematics as a requirement for graduation. In fact, as this is being written, a newspaper item states that mathematics will no longer be required for graduation from Chicago high schools.

The solution of this problem is not completely furnished by a more-or-less scientific selection of suitable entering material at the front door of the engineering college because already 60 per cent of the entering students come from the upper third in scholarship of the high schools and only 3 per cent from the lower. These are problems concerned primarily with the public school, as only 10 per cent of the entering students prepared at private institutions. The problem of the high-school

(*Continued on page 370*)



COMPRESSION PLANT OF 5,000,000 CU FT PER DAY CAPACITY
(Plant is operating three wells, which will not flow naturally, by gas lift.)

PRODUCING OIL *by* GAS-LIFT *and* NATURAL-FLOW METHODS

By S. F. SHAW

CONSULTING ENGINEER, OKLAHOMA CITY, OKLA.

NATURAL-FLOW and gas-lift methods have become an important adjunct to the production of crude oil. Owing to the shallow depths at which oil wells were first discovered, reservoir pressures were low, and wells continued to flow for only a short time, after which artificial lifting methods were adopted, and usually some form of plunger pump has been employed. Recently, after natural flow ceases, gas from compressor plants has been supplied to make up the deficiency of gas produced with the oil from the formation to continue flowing methods. This practice has been applied more particularly to the deeper horizons where mechanical pumping methods are increasingly handicapped by the greater depths and by limitations in the size of the openings through which pumping equipment must be introduced into the well.

At various times the statement has been made that the physical laws governing the operation of natural flow are identical with those governing the operation of the gas lift. Conditions of operation under which gas lift is employed may be different, but if the same conditions exist in natural flow, the lifting results are identical.

DISCOVERY OF AND THEORY UNDERLYING THE AIR LIFT

The air lift is supposed to have been discovered by Loescher in 1797 and has been employed at various times since for lifting liquids. At present, it is widely used to lift water for domestic, municipal, and irrigation purposes, and yet scarcely any subject of a mechanical nature is so inadequately understood as is the operation of the air lift. Practice has provided numerous examples to guide the engineer in applying it to various purposes, but, when he steps outside of the ground already covered, he is entering an uncharted region with nothing to guide him except his ability to perform experiments in the unexplored territory.

Various theories have been offered to explain the action of the air lift in raising a liquid. Perhaps as clear an explanation as any yet offered would be a comparison with the wind's action in scarcely raising the finest dust when the breeze is very gentle, and yet, when the velocity becomes sufficiently great, as in the path of a tornado, even very large buildings may be torn up and transported for considerable distances. The air, in a windstorm is moving from a high-pressure area to one of lower pressure; likewise, in air-lift operations, the compressed air or gas is moving from a high-pressure point at the bottom of the well to one of lower pressure at the surface, its path being confined to the area of the pipe. The air lift will not function at all if no differential pressure exists between the bottom and the top of the flow pipe, neither will it operate unless sufficient velocity is attained to carry the liquid along with it.

When oil or water is being produced from a well, the rate of inflow will depend upon the rate at which the liquid is removed from the well. Pressure at the well bottom will depend upon the rate at which the liquid is being removed. The compressed air, or gas, entering the bottom of the well and mixing with the liquid, must be under a pressure equal to that produced by the latter as it enters the well, else it cannot enter the well and mix with the liquid. The producing rate establishes various conditions, all of which must be understood and provided for, if the engineer hopes to maintain successful control of the gas-lift operation.

If a flowing well could be removed to a laboratory and its operation carefully scrutinized under the multiplicity of conditions that exist, an understanding of the factors involved would be reached much more quickly and clearly. Inasmuch as this cannot be done, conclusions must be arrived at by making numerous observations of pressure conditions at the bottom and the top of the well and the quantity of liquid and gas being

moved. This requires years of patient work and can be done only as opportunity is afforded; no other method of approach is known at present. Capital cannot be induced to drill expensive holes several thousand feet deep merely to experiment with gas lift. Waiting until an oil well is drilled, which may provide opportunities for the operator to profit and for making observations while producing the oil, is necessary.

FACTORS INFLUENCING GAS LIFTING OF LIQUIDS

The principal factors that influence raising a liquid by gas lift are as follows:

(1) Diameter, length, and roughness of the surface of the pipe, often called the eductor pipe, through which the lifting takes place.

(2) Pressure at bottom and top of the eductor pipe.

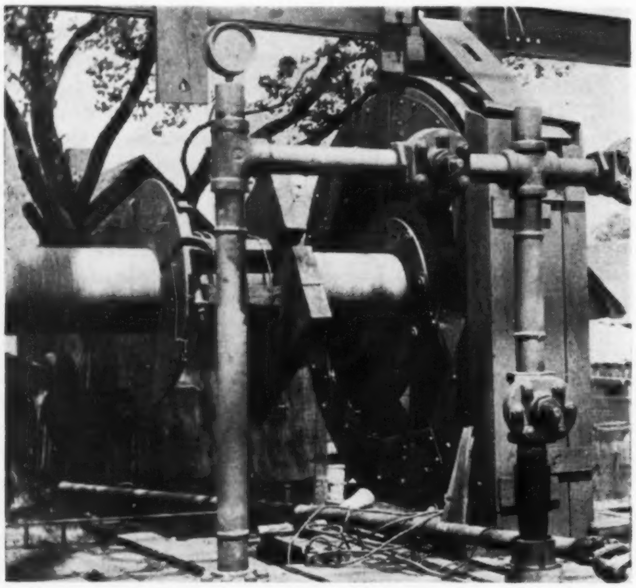
(3) Density, viscosity, and temperature of the liquid being lifted.

(4) Density, viscosity, and temperature of the gas employed in the lifting operation.

The quantity of liquid that can be lifted through a pipe will vary directly as some function of its diameter and inversely as some function of its length. Interior-surface roughness will affect the capacity of the pipe markedly, although no known criteria that can be used as a guide exist. All that can be said about roughness is that keeping the surface of the pipe clean is very important.

Comprehensive formulas to determine the capacity of a given pipe under any and all conditions are available. Where sufficient observations have been made with a pipe of given length and diameter, under different conditions of pressure, and with a given character of liquid, an empirical formula that will cover fairly well the relations between pressure, capacity, and quantity of gas required to lift a unit quantity of liquid in gas-lift operations can be stated. If, however, the pipe diameter or length is changed, an entirely different formula must be used.

The pipe's capacity will be affected directly as some function of the pressure at the lower end and inversely as some function of the pressure at the discharge end of the eductor column. Higher pressure at the bottom of the pipe implies the storage of more energy in a cubic foot of gas than if the pressure is lower; consequently, in expanding from the higher pressure, more energy is available for lifting the oil. On the other hand, higher pressure at the discharge end of the eductor means that less energy is available for lifting purposes than if the discharge pressure were lower.



GAS-LIFT HOOKUP ON WELL IN WILCOX SAND, OKLAHOMA CITY
(Initial production was 100,000 bbl on natural flow. On ceasing to flow naturally, it was placed on gas lift and produced 8500 bbl a day.)

Density of the liquid will affect the capacity of the flow string and the pressure required to lift the liquid. On the Gulf Coast, molten sulphur is being raised by air lift and requires a much greater volume of air for a given volume than is required to lift an equivalent volume of the light oil such as is being produced at Seminole and Oklahoma City.

Viscosity of the liquid being lifted has an important bearing on the eductor's capacity. Observations have been made where, under identical pipe diameter and length, the volume of gas required to lift a barrel of oil of 22 Bé gravity was almost double that required for the same quantity of 36 Bé oil, and the pressure required for the heavier oil was considerably greater. The difference in density of the oils alone would not be sufficient to explain the difference in the gas volume and pressure required for the lifting operation, and the logical explanation seems to be that it is due to viscosity.

Temperature of the liquid will have a bearing on whether heat is abstracted from or added to the gas, and this, of course, affects the energy it possesses. However, the oil temperature probably has a greater influence on the lifting operation through its effect on the viscosity of the oil.

SIGNIFICANT POINTS OF GAS-LIFT OPERATION

Four points are of significance in gas-lift operations under a given set of conditions of pipe length and diameter and pressure at the top and bottom of the pipe. They are

(1) Point of no flow, caused by the quantity of gas being just insufficient to start a flow. Up to this point, the gas bubbles through the liquid without attaining sufficient velocity to start flow.

(2) Point of flow where maximum lifting efficiency is obtained.

(3) Point of flow where maximum capacity is obtained. If the quantity of gas be either less or greater than that giving maximum flow, the capacity of the pipe will be reduced.

(4) Point of no flow caused by presence of excessive gas.

Establishing the last point is difficult when the pipe diameter is large, due to the very large quantity of gas required. In small pipes, however, this point is not difficult to determine, because sufficient gas that can be admitted to the pipe for this purpose is usually available. In other words, the friction loss caused by gas escaping through the eductor pipe is equal to the pressure at which the liquid would enter the well; consequently, no oil or water will flow into the well under a pressure that is equal to, or greater than, that existing in the oil sand. If the friction loss is greater than the pressure at the bottom of the well, some gas will escape into the oil sand. In various oil fields, the quantity of gas escaping from the formation through some wells on high points of the structure has been observed to be so great that no oil can enter the well and be produced with the gas. The remedy in such a case is the use of a larger casing string. However, once a casing string has been set, removing it, reaming the well, and setting a larger casing would be very costly.

In the operation of oil wells, all of the foregoing factors must be observed carefully to obtain satisfactory results. First, the well must be completed with the casing size that will enable the well to produce at an efficient rate. The first well, or wells, must, of necessity, be test wells, to determine many

factors; first the depth, which governs the length of the flow string; and next, the quantity of oil that can be produced, as this governs the diameter of the pipe to be employed.

After the casing is set in the well, the engineer must determine the best rate of flow at which to produce the well. In natural flow, the quantity of gas cannot be limited to that required to flow the well at maximum efficiency or capacity, since the oil contains a given quantity of gas in solution, all of which reaches the well and must be produced with the oil. This may be compared to the production of water containing various salts in solution; the water cannot be produced, leaving the salts behind.

ENGINEER CAN CONTROL QUANTITY OF GAS REQUIRED

In artificial gas-lift flow, the quantity of gas required for the desired rate of production, whether this be very low, at maximum efficiency, or at maximum capacity, lie within the control of the engineer. After he has received sufficient training in this work, testing the well and then providing control rates for handling production is comparatively simple.

In making tests, the point of flow having greatest importance in oil-well production is that of maximum capacity, and this should be employed as a standard in guiding the operations at any given period in the life of the well. The point of maximum efficiency should also be observed, and test observations should cover the range from just under maximum efficiency to slightly beyond maximum capacity. A test of this nature is shown in Fig. 1, where the points of no flow, maximum efficiency, maximum capacity, and no flow caused by excessive gas are indicated by *a*, *b*, *c*, and *d*, respectively. The testing range should slightly overlap that between *b* and *c*.

With the two most important significant points determined, the engineer is prepared to compute the lifting efficiency at the rates of maximum efficiency and maximum capacity. Different methods of calculating the efficiency have been employed, but the simplest and most useful is to consider that the lift consists of the distance between the operating level of the liquid and the point of delivery and the energy is that available at the pressure existing at the entrance to the eductor pipe, and to disregard any lifting benefits other than those resulting from raising the liquid from the liquid level to the delivery point at the surface.

To evaluate exactly the work done in expansion of the reservoir gas is exceedingly difficult, if the gas is not considered as a perfect gas; also, the consideration of isothermal, rather than adiabatic or some intermediate type of expansion, greatly simplifies the calculations. Probably the relations between the character of the gas employed in the lifting operation and a perfect gas and between isothermal and the actual type of expansion remain sufficiently constant throughout the operation so that the net results are not measurably affected by employing the method that is given herewith, especially when the efficiency determined by tests is computed on the basis of the overall results obtained.

The well-known formula employed for the work developed during isothermal expansion of a cubic foot of a perfect gas at sea level is

$$W = 144 \times 14.7 \log_e (p_1/14.7) = 4874 \times \log_{10} (p_1/14.7) \quad [1]$$

where p_1 is the pressure in pounds per square inch absolute from which the gas expands and W is the number of foot-pounds of work actually performed.

The foot-pounds of work, W_1, performed in lifting a barrel of water to a given height in feet, h, is

$$W_1 = 350 \times h \quad [2]$$

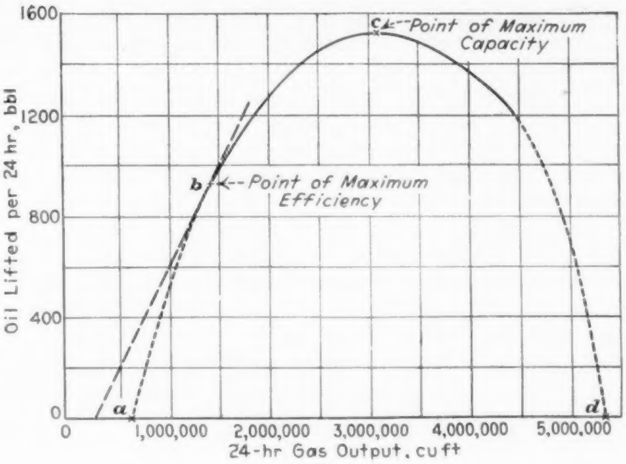


FIG. 1

The quantity of gas Q_g, in cu ft required to lift a barrel of water to a given height h, is then

$$Q_g = 350 \times h/[4874 \times \log (p_1/14.7)] = 0.0718 \times h/\log (p_1/14.7) \quad [3]$$

The quantity of gas obtained from formula [3] is based on no losses of any kind or 100 per cent efficiency, which, of course, is never the case. As an approximate rule, the percentage of lifting efficiency should very closely approach that of submergence when operating at maximum capacity. The latter percentage is obtained by dividing the number of feet of liquid, based on the operating level or its equivalent in pressure, by the total length of the eductor column.

Under conditions of high submergence, experience has shown that the percentage of lifting efficiency is less than that of submergence; while with very low submergence, the former percentage may be several times the latter. Within the general range employed in oil-field work, between 10 and 20 per cent submergence, the lifting efficiency may roughly be taken as equivalent to the percentage of submergence. Formula [3] then becomes

$$Q_g = 0.0718 \times h/[S \times \log (p_1/14.7)] \quad [4]$$

where S is the percentage of submergence.

The capacity of a given diameter and length of pipe cannot as yet be expressed in the same manner as that in which the quantity of gas required is determined. A large number of tests must be made under various conditions of submergence for the particular liquid being lifted. In gas-lift operations at Seminole, something like 10,000 tests were made from which the following empirical formulas were derived for the operations in that field and for that particular character of oil.

For 3-in. tubing $p = 10.22\, Q^{0.465}$ .... [5]

For 4-in. tubing $p = 3.965\, Q^{0.507}$ .... [6]

For 7-in. outside-diameter casing with $2^1/_2$-in. upset tubing $p = 2.546\, Q^{0.554}$ .... [7]

For $8^5/_8$-in. outside-diameter casing with 3-in. upset tubing $p = 1.021\, Q^{0.617}$ .... [8]

For $8^5/_8$-in. outside-diameter casing with 4-in. upset tubing $p = 1.166\, Q^{0.62}$ .... [9]

In these formulas, p is the bottom-hole flowing gage pressure, and Q is the number of barrels of oil per 24 hr that can be lifted at maximum capacity.

The various factors for determining the proper method of

producing oil cannot be ascertained without making an exhaustive number of observations, and this cannot be done until the various oil companies are in a sympathetic mood. Doing the work entails a certain expense, but my experience has been that the immediate rewards to the operator are several hundred times greater than the expense involved. The greatest handicap to investigating gas-lift operations is the lack of engineers trained in this method of producing oil.

EXPENSE OF GAS-LIFT OPERATION

The cost of furnishing compressed gas in natural flow is, of course, practically nil, since the gas is produced with the oil, and the lifting cost is, therefore, low. However, improper handling of wells on natural flow and nonobservance of orthodox gas-lift principles can reduce the returns to the operator very much from those possible with efficient methods. Using proper pipe sizes in natural flow has a large bearing on the financial outcome from the operation of the well.

When artificial gas lift must be employed, a low expense for compressing gas or the availability of high-pressure gas from a well near by may enable the lifting expense to be low despite inefficient application of the gas to the lifting of oil. On the other hand, use of a high-cost gas could easily result in a high lifting cost per barrel of oil, even when the application of the gas is efficient. For instance, when the maximum capacity of a 6500-ft well is reduced to a productive rate of only 100 bbl per day, the quantity of gas required may be 25,000 cu ft per bbl in wells completed with small-diameter casings, depending on various conditions. At 7 cents per 1000 cu ft, the charge for gas from commercial high-pressure lines in the Oklahoma City field, the lifting cost is $1.75 per bbl. On the other hand, gas at pressure of 400 lb is being compressed in a plant in this field, which is especially adapted to the use of gas lift in a group of wells, at an operating cost of 0.8 cent per 1000 cu ft. The lifting cost, even at a consumption of 25,000 cu ft per bbl, would then be only 20 cents per bbl. This example illustrates the point that low-cost gas from a plant that has already paid out, when operating under favorable conditions, can be employed for lifting oil in the later stages of the well, even if the conditions are difficult to handle.

The question of producing gas at a low cost, with due regard to existing conditions, is just as important in gas-lift operations as is the operation of a power plant in any industrial enterprise. That a compressor plant can be operated at a lower expense if the discharge pressure is low instead of high and that maintenance expense will be greatly increased if the plant is overloaded seems to have escaped the attention of many oil operators. To operate at low pressure, the pipe lines carrying gas to the well must be of the proper diameter if friction losses are to be the minimum. Also, to deliver gas to the bottom of the well with minimum friction loss, the tubing must be as large as possible, and, to permit using large-diameter tubing, the well must be completed with the proper size of casing. Therefore, to insure low operating costs and low capital expenditure for the plant, the operator must develop his production plans before drilling the well so that the casing and tubing diameters in the well will be the best sizes and the gas lines on the surface will be of the proper diameter. In an industry of such magnitude as the oil business, the little regard that is paid to these vital factors is surprising.

In one area of the older part of the Oklahoma City field, the reservoir pressure has declined to 130 lb. When casings of $6^5/_8$ in. diameter are employed, the maximum production on straight gas lift with this reservoir pressure is approximately 60 to 100 bbl per day, and the consumption of input gas for lifting oil is 25,000 cu ft or more per bbl. On the other hand, when the wells are completed with $9^5/_8$ in. outside diameter casing, the maximum production at this pressure is about 2000 bbl per day and the quantity of gas required is approximately 2000 cu ft per bbl. When the pressure has declined to 61 lb, the production on straight gas lift through $9^5/_8$-in. casing is 550 bbl per day in actual operation, and the consumption of gas is from 6500 to 7500 cu ft per bbl. In another instance, where the bottom-hole flowing pressure is 46 lb, the production is 525 bbl per day, and the output-gas consumption is 5560 cu ft per bbl.

When gas can be compressed at 0.8 cent per 1000 cu ft for operating costs, or a total of 2 cents per 1000 cu ft including depreciation, the lifting cost is rather low. No reason seems to exist why wells in the Oklahoma City field with proper casing sizes cannot be produced on straight gas lift until the reservoir pressure has declined to 20 or 30 lb per sq in. before the economic limit is reached. When that pressure is reached in this deep field, whether any method known at present can be employed profitably is doubtful.

In Oklahoma City wells, equipped with $9^5/_8$-in. casing, which are capable of making a production of 2000 bbl per day on straight gas lift, the common practice is to install Reda centrifugal pumps, with the packer set from 300 to 1000 ft above them, and use gas lift to raise the oil from the packer to the surface. Under these conditions and with this combination method, about 5000 bbl of oil can be produced per day with an approximate per-barrel consumption of 1250 cu ft of compressed gas and $^3/_4$ kwhr of electric current.

Reducing Radiation Errors in Gas-Temperature Measurement

(Continued from page 334)

to prevent short circuits. The hot junctions were at approximately the halfway point of the portion of the tube carrying the heating coil which was about 10 in. long. The wattage input of this heating coil was measured with a voltmeter and an ammeter. The two tubes were mounted so that their longitudinal axes coincided. The millivolts of the two couples were measured with a Leeds & Northrup service potentiometer. These readings were converted to degrees centigrade from the calibration curves. The results which were obtained are shown in Fig. 1.

Over the period from 20 to 40 min, a fairly uniform difference of temperature exists between the two couples showing a temperature gradient with radiation losses to the flue, the annular space being colder than the central space. Between points *A* and *K*, the heating coil was adjusted over a range of 1.3 to 5.4 watts until the two couples read the same. No net loss from the central to the annular space and, therefore, no appreciable lowering of the central thermocouple temperature due to lateral radiation could then occur.

More gas was then turned on in the furnace, and the central thermocouple immediately began to gain on that in the annular space. At *L*, the heating coil was again turned on and adjusted through points *M* and *N*. At *O*, the furnace heat was cut down, and, at *P*, the heating coil w s cut to zero. In this region, the time lag is again apparent. The furnace is cut off, and the two couples coast down to room temperature.

This time lag requires a modification in the thermal conductivities of the tubes. To connect the two couples through a vacuum-tube circuit to operate a mechanical or electrical device for switching the heating current on and off would be a simple matter.

MODERN RICE-IRRIGATION SYSTEM

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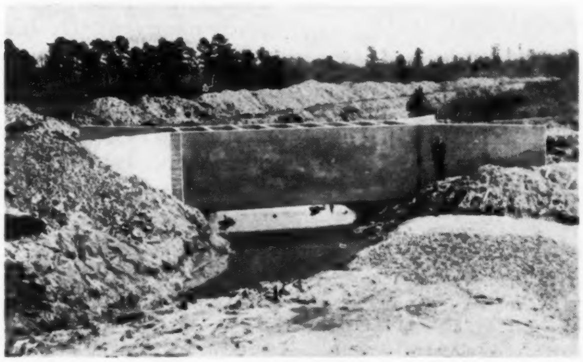
MODERN RICE culture, as carried on in the Gulf Coast region, had its beginnings in the eighties and early nineties when the Southern Pacific Railroad brought many settlers from the Middle West to the prairies of southwest Louisiana. These men found the Acadian farmers growing rice for their own use and they proceeded to plant rice as they had been accustomed to plant wheat, on a scale that would make the crop of commercial importance, by using labor-saving machinery. The Acadians dammed back a small supply of water in a field or trusted entirely to Providence for water. The new settlers saw abundant water supplies and proceeded to pump water from rivers and bayous to irrigate the crops.



CONCRETE FLUME ON MAIN CANAL

Water is supplied when the plants are from 4 to 6 in. high. The irrigation period depends upon varieties and weather conditions but usually is between 70 and 120 days. Contour levees are used; the difference of level usually is from 0.2 to 0.3 ft. Water is drained off a few days before the crop is ready for harvesting.

For many years, the unit of design for pumping plants and canals for rice irrigation was 10 gpm per acre watered. In the early days, it was often as low as 7.5 gpm. Experience has taught that even the larger figure is too small. In recent years, the practice has been to unwater rice fields after an initial flooding, which was applied principally to arrest the growth of grasses and insect pests, thus allowing the plants to stool and the root system to spread and strengthen. The fields remain dry until the effect is noted on the crop, when water is again applied and held until the rice matures. The necessity for effecting the second application promptly has raised the unit of design to 12 gpm per acre.

DUTY OF WATER

The gross duty of water in rice irrigation, in depth for area irrigated, is approximately as given in Table 1. While the quantity of flood water required for individual fields varies within wide limits, experience of the larger companies shows that, in spite of rather great fluctuations in seasonal rainfall, between 26 and 32 in. of water must be pumped for irrigation in addition to an average rainfall of 18 in.

TABLE 1 GROSS DUTY OF WATER IN RICE IRRIGATION

	Depth, in.
Transpiration	15 to 18
Evaporation	11 to 14
Seepage	2
Loss in transit	2
Waste	14
Total	44 to 50

Part of the 14 in. wasted is accounted for in careless and inefficient irrigation. A large portion is lost during storms when the additional depth of water overtops the field levees, resulting in a loss of field water as well as the rainfall itself. The extent to which waste can be reduced and the duty of water increased is limited. Savings in cost of pumping to replace water lost by waste may not justify the excessively large field levees necessary to eliminate this waste.

ORANGE COUNTY IRRIGATION PROJECT

The Orange County irrigation system is located in southeastern Texas, and takes water from the Sabine River Narrows. Its 85 miles of canals and laterals will serve an area of approximately 56 sq miles. About half of this district, 18,000 acres, will be planted with rice in alternate years, and the irrigation system is designed to provide sufficient water to irrigate these fields annually. Based on a supply of 12 gpm per acre, the water requirement of the rice fields is 216,000 gpm. The specifications for the pumping plant required sufficient capacity to pump this quantity of water or 480 cfs against an average actual lift of 22 ft from suction to discharge basins, the minimum and maximum heights being 17 and 24 ft, respectively.

Under the present economic conditions in the rice territory of southwestern Louisiana and southeastern Texas, careful analysis of a pumping problem usually results in the selection of a Diesel engine driving a centrifugal or a screw pump. Irrigation water can be pumped by electrical energy, but it will be done at a considerably increased cost over Diesel engines, while steam engines are entirely out of the running.

Specifications for the Orange County pumping plant provided for four Diesel engines, each driving a direct-connected centrifugal or screw pump. The equipment selected was 440-hp McIntosh & Seymour Diesel engines and 48-in. screw pumps built by the Morris Machine Works.

The engines and pumps rest on a reinforced-concrete mat 18 in. thick which is supported by piles spaced on 4-ft centers. An independent pile foundation is provided for the building, and the joint between it and the mat for the pumping equipment is sealed with copper flashing.

TESTS OF PUMPING UNITS

Tests of the pumping plant were made before the canal system was completed. A dam of yellow clay was left in the main canal, about a half mile from the plant. Operation of a unit for a short time filled the canal to the level of the dam and then overflowed the dam, maintaining a practically constant discharge level. The level of the suction basin varied but little during the runs. From gages set in suction and discharge

From a paper contributed by the Hydraulic Division and presented at the Semi-Annual Meeting, Dallas, Tex., June 15–20, 1936, of The American Society of Mechanical Engineers.

basins, the water levels were read, and the vertical lift determined.

Fuel oil for the tests was weighed in 15-lb quantities and time for using each lot accurately recorded. The quantity of water pumped was determined by pitot tubes. Observations were taken after the unit had settled down to constant conditions of operation. The results of the tests are given in Table 2.

TABLE 2 RESULTS OF PUMPING-PLANT TESTS

Unit	1	2	3	4
Mean lift, ft	20.56	20.65	20.30	20.24
Speed, rpm	310	309	304	308
Length of run, min	92.67	89.16	75.00	79.83
Fuel consumption, lb				
Total	255.5	240.0	195.0	210.0
Per min	2.65	2.69	2.60	2.63
Water pumped, gpm	61,162	62,250	60,400	62,150
Water pumped per pound of fuel, gal	23,080	23,150	23,220	23,600

Averaging the tests of the four units showed that 23,262 gal was pumped per pound of fuel against an average mean lift of 20.44 ft. This figure was approximately 3 per cent less than the builder's guarantee of 24,000 gal per pound of fuel against the average head, and, as an engine-fuel tolerance of 3 per cent was permitted, acceptance of the plant was recommended.

CANALS AND FLUMES FOR SUPPLYING WATER

A characteristic of the Gulf Coast is its flat topography which imposes upon a designer the necessity of dealing with excessively flat slopes in connection with many structures for irrigation canals. In general, these slopes are an asset to operation because they eliminate dangerously high velocities, stabilize withdrawals from the system, and reduce the investment in checks and drops. Their apparent adverse effect on canal capacity, in requiring excessively large cross-sectional areas is overcome by setting the levees far enough apart to borrow all earth needed for construction from between them. This usually results in an oversize section but, at the same time eliminates objectionable borrow pits.

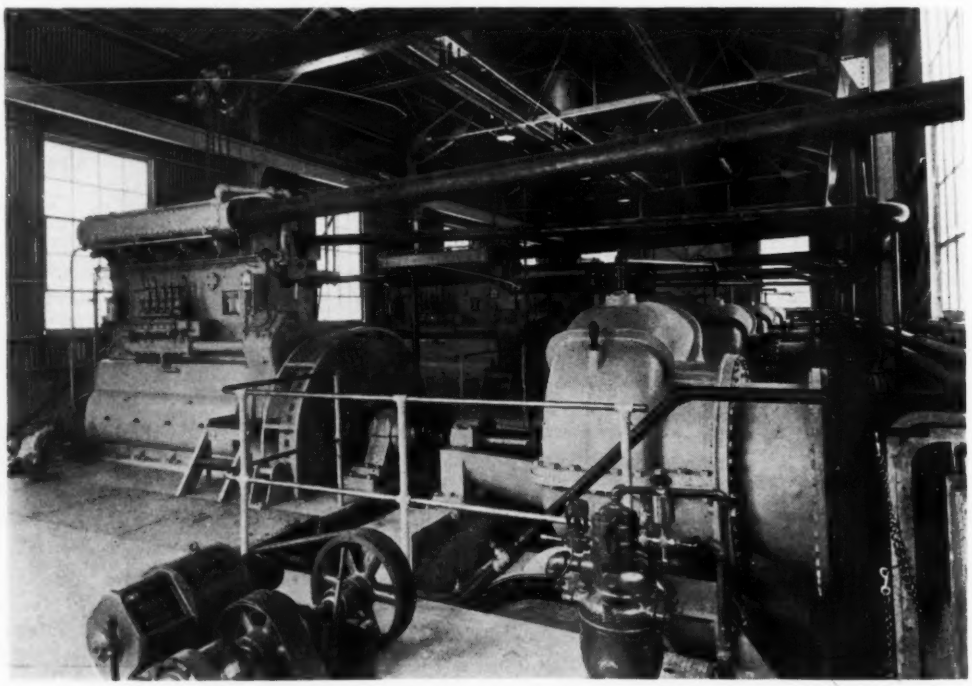
The canal system of the Orange County project consists of new construction and portions of six smaller canals that were abandoned many years ago. On the latter, reconditioning of old levees and, in some cases, adding to their height and section were required. New levees were constructed by draglines and an elevating grader. The latter was used on new construction where more favorable drainage and borrow-pit conditions permitted its economical use. Existing levees were topped and reshaped with draglines supplemented by hand labor.

The Cow Bayou flume of the project is a semicircular structure of No. 14 galvanized sheets supported by a substructure of creosoted timber. The diameter of the channel is slightly less than 11 ft, and the length is 837 ft. Other factors relating to the flume are Q = 150 cfs with a 1-ft freeboard and 170 cfs with a freeboard of 0.6 ft; S = 0.0004; and V = 4.36 fps.

All other flumes are of reinforced concrete, of which the one on the main canal is typical. The design utilizes the walls as load-carrying girders, the depth of which has been fixed at 9 ft 4 in. by the required capacity of the channel. Width has been standardized at 10 ft, and the economical length is 32 ft. For these flumes, Q = 488 cfs when V = 6.1 fps.

For the smaller sizes of checks, turnouts, and gates, concrete-pipe structures are used. The gates are of precast concrete, fitting in metal or treated-timber slides. Where greater capacity is required, reinforced-concrete structures with hoist-controlled slides have been installed.

All state highways are crossed by reinforced-concrete siphons. County highways are crossed with treated-timber bridges or concrete-pipe siphons. Irrigation water is carried under railroad right of ways through corrugated-iron pipe structures with appropriate headwalls and transitions. Where it can be done economically, drainage is carried under the irrigation canal through concrete-pipe siphons, and, at the larger drainage crossings, reinforced-concrete siphons are installed.



FOUR 48-IN. SCREW PUMPS, EACH DRIVEN BY A DIRECT-CONNECTED 440-HP DIESEL ENGINE, HANDLE THE WATER REQUIRED TO IRRIGATE THE RICE FIELDS

THE PROBLEM OF INVESTMENT

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IN A distinctly interesting and readable yet thoughtful monograph,[1] the author examines the change-producing forces that have combined to make the work of successful investment increasingly difficult. The influence of these forces and the problems they present are analyzed with care, and suggestions are offered for economic reforms that would, perhaps, remove some of the difficulties encountered by those who face the problem of caring for capital funds.

The world is passing through a period of bewildering change. No manifestation of this process is more startling than the swing of investment values from heights of fantastic figures in the late so-called "new era" to the destructive depths of more recent days. This collapse, moving with unprecedented speed, has spared no one in its ruthless attack on fancied security and compels a re-examination of the whole investment field and the conditions that surround it. These conditions, economic and political, seem to undergo change at an accelerating rate, and thus changing render invalid, almost overnight, previous conceptions of what constitutes security for one's savings. What influences and forces are operating to produce and perpetuate the bewilderment that exists?

PROBLEMS ARISING FROM TECHNICAL DEVELOPMENTS, MODERN CORPORATIONS, AND SECURITY AFFILIATES

First, technical developments flowing from the ingenuity of human minds working in a period of dynamic industrial research render obsolete today the article whose production yesterday invited our money. Synthetic production of nitrogen makes the world practically independent of Chile as a source of nitrate supply and Anglo-Chilean Nitrate Company bonds become worthless. Developments in the electrical and gas industries bring chaos among the coal companies. Ten years' growth in chain stores destroys or seriously threatens the existence of the independent merchant and the onrush of automobile and airplane transportation carries a menace to savings locked up in railroad bonds. All this represents nothing new in principle. It has always existed, but the accelerating speed with which such changes now occur challenges the best efforts of investors in their attempt to use safely and profitably the capital at their command.

A new creature in the world—the modern corporation with its many conflicting interests and its separation of ownership from control—operates to place the small investor in the position of one who receives mere wages of capital for the use of the money he saves. He has little or nothing to say about how much he shall receive for the use of that capital, because by intricate though effective corporate devices, management exerts control without authorization from, or responsibility to, ownership. In rapidly increasing measure giant industry moves to take over the control of our industrial life. Investors find themselves substantially without alternative to the purchase of the securities of these same giant companies, whose charters have been drawn so that the interest of management may be enhanced at the expense of real proprietorship. Multiplication of holding companies, abuse of the voting-trust principle, the use of nonvoting or proportional-voting stock, parasitic shares, and other varieties of legal arrangement are among the devices of modern creation that bring despair to the investor seeking protection in the old-time idea that ownership meant control. Add to this the further fact that the price ticket on one's property is being changed from day to day in a market itself subject to manipulation and exploitation by inside pools, and it becomes glaringly apparent that corporate securities offer at best a doubtful medium for the commitment of the savings on which one's security depends.

And the banks enter the scene to complicate the problem and confuse the minds of investors. Departing from their traditional activities as mere middlemen for depositors and borrowers, hundreds of our banking institutions became associated with so-called "security affiliates." Being human beings, with the frailties of other human beings, bank officials, who often advised their customers on investment matters, turned them over to the affiliate. In itself this was not necessarily detrimental to the customer's interest, but it frequently happened that the affiliate proved to be a convenient agency for "bailing out" the bank, by buying from it investments of uncertain merit at prices substantially higher than the market would have offered.

Thus the investment public, depending on what is usually considered conservative judgment, served as a medium for relieving the banks of their slow and uncertain loans. Even more important, in the aggregate, has been the influence of banks (principally investment banks) in the flotation of huge volumes of foreign securities. The ill-fated Kreuger and Toll episode and the scandalous activities of Juan Leguia, son of the president of Peru, in the sale of Peruvian bonds through the agency of American banks are but two of the most reprehensible pieces of foreign financing indulged in by such institutions. It is to be noted that postwar legislation in the form of the new Banking Act and the Johnson Act have undertaken to correct some of these evils and to prevent their re-appearance.

THE CHANGING POSITION OF THE MORTGAGE HOLDER

The evolution of the law has altered in a profound manner the older relationships between borrower and lender and has made vague and uncertain the line between risk-taking speculation and conservative investment. Indeed, the episode of recent bank failures superimposed upon an era of collapsing security values suggests convincingly that all investors are speculators. Prominent in the evolution of the law of investment relationships is the changing position of the mortgage holder. It is a long step from the time when a defaulting mortgagor might lose his property without even enjoying the equity of redemption, through the intervening doctrine of the lien theory to such recent enactments as the Frazier-Lemke Act. The original act of this name (ruled out as unconstitutional) completely removed from the mortgagee any effective power of foreclosure and sale, and even the amended act provides for a moratorium of such length and with restraints so far-reaching that the mortgage contract has lost much of its protective

[1] "The Problem of Investment," by F. I. Shaffner, John Wiley & Sons Inc., New York, N. Y., 1936.

One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers.

power in so far as the mortgagee is concerned. More important still, in magnitude of influence at least, is the development of the law governing foreclosure of corporate mortgages. He who would attempt to exercise his legal rights in such cases will find himself confronted at every turn with a maze of practical difficulties. First, there is the confusingly complex and lengthy indenture that baffles interpretation even by experts in finance and law. Then there are the numerous loopholes through which evasion may take place, destroying the presumed protection that the mortgage should give. Examples of such evasion may be seen in the methods used to nullify the effect of the after-acquired property clause or to obtain relief from sinking-fund requirements. Then again the passive attitude taken as a matter of course by practically all trustees under mortgage agreements means that such functionaries are trustees in name only. Indeed, most mortgages contain immunity or exculpatory clauses specifically absolving the trustees from responsibility for the performance or nonperformance of acts other than those of a purely ministerial nature and for acts of bad faith.

Finally, in the evolution of the law, receivership proceedings have come to be so tied up with questions of the general good, the public interest, the clash of interests within the corporation, and business expediency that equity rather than contract rights governs the action. It follows that, almost without exception, senior security holders emerge from such receiverships and reorganizations without payment and in a weakened position relative to that originally assumed. All this operates to whittle away the protection presumably enjoyed by the holders of mortage bonds. Regrettable as it may appear to be, it was probably inevitable that such a development should take place in our bafflingly complex industrial society. Moreover, it is doubtful that the strict enforcement of the letter of their contract would give such bondholders anything of practical significance. The real protection enjoyed by security holders is the income of the business represented by those securities. Seizure of the property, if it were permitted, would usually "result in but a hollow satisfaction where the earning power of the property had disappeared or would disappear if separated from the whole of which it is a part."

From all of the foregoing, it becomes apparent that the position of the secured creditor is being progressively weakened. About the only advantage a mortgage affords, is the priority it gives. In the interest of general social welfare, it is suggested that the mortage bond might well be eliminated from the list of investment media to the end that it, like other rigidities in our economic system, might not operate to retard those adjustments so essential in periods of business depression.

BUSINESS CYCLES AND ATTEMPTS TO CONTROL THEM

One of the most significant among the influences that make the problem of investment difficult is the periodical swing of business from depression to prosperity and back—the so-called business cycle. No one can deny its existence, though some profess to believe that it can be abolished. Nor can it be denied that the task of protecting capital is vitally influenced by its presence. "The type of security, the industry, the type of firm within the industry, the question of whether to be long of the market in stocks or in bonds or cash, and even the country in which the investment is to be made are matters which require a prior appraisal of cyclical position." From the investor's standpoint an important question is whether or not he must always consider this phenomenon, knowing that it will always be with him, or whether it may by legal enactment and economic control be abolished. A review and appraisal of the various theories that have been offered to explain the cycle leads the author to conclude that it is an inescapable concomitant of our modern industrial life. "The achievement of a lasting equilibrium which would preclude cyclical fluctuations under our capitalistic organization of society would have to be based on the assumption that man's expectations as to the future were never falsified and that results would bear out anticipations. It is obvious that when production has to envisage a distant future such an assumption cannot be seriously maintained."

Notwithstanding what appears to be the inevitability of cyclical fluctuations in business activity, numerous plans have been brought forward and are being brought forward to bring about a state of economic stability. Without known exception these plans neglect the fundamental forces that produce business cycles. To eliminate them it would be necessary to eliminate many of our present institutions and agencies of life and to change profoundly the tendency of man to alternate between aggressive action, based on hope, and deadening inaction or retrenchment, based on fear. With convincing argument the author reveals the insufficiency of efforts at controlling the cycle through the process of stabilizing the price level, although it is admitted that central-bank action may be desirable as a balancing force to be used as an offset to speculative enthusiasm. With equal effectiveness he deals with other devices and schemes for obtaining business stability through government planning. Problems to be dealt with and difficulties to be met are analyzed and examined without open condemnation of the effort, but with a clearly defined suggestion that a more orderly and consistent approach than has yet been made is necessary if there is to be any reasonable hope of success. This attempt at a more scientific approach to the problem will be made, however, and the future is apt to see more of such effort rather than less. This the practical investor must take into consideration. The lines that such efforts follow, the methods adopted by the government in its attempts to secure economic stabilization and a more equitable distribution of the national income, and the extent to which government enters into fields of business activity heretofore reserved to private endeavor are all influences projecting unknown factors of doubt and fear into the calculations of those who have money to invest. It is indeed a strange paradox that the efforts of government ostensibly directed toward the reduction of risk and uncertainty should be in fact an additional source of risk and uncertainty against which the investor must as far as possible guard himself. How? The question is unanswered, but the question remains.

IS THERE ANY HEDGE AGAINST INFLATION?

A final item of almost supreme importance to the investor is the prospect of inflation. This is no mere academic question but is a possibility if not a probability in the not distant future. Recovery legislation, including monetary changes, accompanied by continuing government borrowings, set the stage for inflationary developments on a substantial scale. It is apparent, of course, that such an occurrence would affect profoundly the bondholder's position—as it would the position of all whose investments are in dollar contracts. Not only would the purchasing power of income and principal fall in direct ratio to the rise in prices, but of equal seriousness would be the decline in the market value of such investments if one found it necessary to realize on them. The author does not develop any method for hedging against this possibility. Perhaps there is no hedge that is entirely satisfactory, but it is certainly one of the most serious threats that investors face at the moment and it is suggested that bonds and all dollar contracts be in substantial measure replaced by real property or direct claims thereto in the form of well-chosen common stocks.

(*Continued on page 370*)

BRIEFING THE RECORD

Abstracts and Comments Based on Current Periodicals

MATERIAL for these pages is assembled from numerous sources and aims to cover a broad range of subject matter. While no quotation marks are used, passages that are directly quoted are obvious from the context, and credit to original sources is given.

The Engineer and Society

THE JOHNS HOPKINS UNIVERSITY

SPEAKING at the general alumni dinner of The Johns Hopkins University on Feb. 22, 1937, on the occasion of the twenty-fifth anniversary of the founding of the school of engineering at that university, Abel Wolman, chief engineer, Department of Health of the State of Maryland, reviewed many of the optimistic and pessimistic views of philosophers, scientists, and writers on the impact of science on civilization in an address entitled "The Engineer and Society."

Mr. Wolman contended that a future task must be added to the present accepted functions of the engineering profession, that task being the transformation for the "masses" of the creations of science into the opportunities of society. The engineer has a peculiar responsibility in this task of conversion, said Mr. Wolman, since he has been trained to substitute knowledge for guesswork in dealing with technological problems. Engineering education, he continued, might then be required to extend its task beyond the technological to the collateral fields of human relations, economics, and finance. It should assume the responsibility of building "the men who are quick to apply the knowledge of the time to the needs of the times."

Using as an example the recent floods of the Ohio and Mississippi rivers, Mr. Wolman proceeded to outline some of the difficulties involved in a satisfactory solution of the flood problem.

The handling of a single resource in this typical basin of the United States, he said, dramatizes at once the issues of local versus central financing and administration. When the collateral undertakings in land use, involving soil-erosion control and forestation, and of power, navigation, water supply, and disposal of wastes intrude into the picture, the confusion of governmental agencies, of divisions of responsibility, of assessments of benefits and damages, of overlying responsibility for operation during periods of flood crests and during drought, all rise up to plague those simple minds who cling either to states rights or to federalism and then retire peacefully to slumber.

Perhaps engineering analysis and conscious translation of complex data into workable formulas, he continued, may bring order out of chaos in this kind of an enterprise. If we may indulge in prophecy, he said, the people will strip the undertaking of its complications and will rush to simple expediencies, such as central governmental mechanisms, regardless of their dangers and of their untested nature. It is no answer to state that such steps by the people infringe upon the existing symbols of government. Some more adequate answers must be provided by those most competent to lead us out of these administrative wildernesses.

In this new kind of pioneering, he concluded, as distinct from the simple geographical pioneering with which we are all familiar, the engineer and the scientist must take the lead. The adaptation of our natural resources and of our familiar structural machinery of government to new or more complex problems appears to offer a fruitful, important, and challenging field for the scientist of tomorrow. In accepting this challenge, he said, this University [Johns Hopkins] and its engineering school must take the lead. Upon them rests the great responsibility of so preparing the intellectual ground of their graduates as to meet these issues with courage, honesty, and ability. These seats of learning must see to it that in their distribution of the tools of knowledge they provide their graduates with the technique and attitude necessary to sustain our cherished liberty by the orderly processes of government and law.

The university likewise, he asserted, must extend the horizon of the "departmentalized" mind of the engineer and produce a greater realization of the problems of the times and of the wider duties and responsibilities which these problems will entail upon their calling in the future. The engineer cannot evade assuming jurisdiction for studying the solutions for some of the issues which his contributions have created in the past and will continue to develop in the future.

Technology and the Consumer

MACHINERY AND ALLIED PRODUCTS INSTITUTE

IN THE fourth of its series of booklets on the relation of technology to the American standard of living the Machinery and Allied Products Institute discusses the relation of machinery to consumer purchasing power as reflected in wages of factory workers and prices of manufactured goods. The pamphlet is entitled, "Technology and the American Consumer."

Following several pages devoted to statistics presented in tabular and graphic form, and briefly discussed, is a section under the heading "Shopping in 1914 and Today." Of 20 articles listed it is shown that prices were less in 1936 than in 1914 and that the increase in wages from 24.7 cents an hour in 1914 to 62.4 cents an hour in 1936 made it possible to earn enough to buy the items with 1883 hours of work in 1936 whereas it required 5138 hours in 1914. The average factory worker could obtain these commodities in 1936 with less than 37 per cent the effort required in 1914. The advantage in terms of weekly or yearly wages is slightly less because hours worked declined during the period.

The general price level of all commodities in 1936 was about 21 per cent higher than in 1914, according to the United States Department of Commerce wholesale commodity price index, based on 784 commodities. Neither the year 1914 nor 1936 was one of outstanding prosperity or of depression. Prices and wages were on an upward trend in both years.

Of the items studied under the twenty headings, in Table 1, 10 showed increases in price, the increases varying from 6.56 per cent in the case of dinner dishes to 89.3 per cent in the case of sewing machines. Ten items showed declines in price, vary-

TABLE 1 PRICES OF WIDELY USED MACHINE-MADE PRODUCTS AND PURCHASING POWER OF FACTORY WAGES IN 1914 AND TODAY

	Price[1]		Hours for factory worker to earn[2]	
	1914	Today	1914	Today
Clothing (year's supply for family of four)	$175.00	$218.00	708.5	349.4
Hats, men's felt	2.85	2.15	11.5	3.5
Shoes, men's work	2.30	2.10	9.3	3.4
House furnishings (30 articles)	100.00	174.00	404.8	278.8
Bedroom suites, 3-piece	25.75	48.55	104.3	77.8
Axminster rug, 9 × 12 ft	20.95	30.30	84.8	48.5
Baby carriage	10.15	8.95	41.0	14.3
Dishes (dinner set)	9.90	10.55	40.0	16.9
Washing machine (electric)	46.25	44.10	187.2	70.6
Sewing machine	16.90	32.10	68.4	51.4
Light bulb (60-watt)	0.43	0.12	1.7	0.2
Electric fan	12.20	3.75	49.4	6.0
Automobile (average wholesale, 1914 and 1936)	761.20	536.00	3081.7	859.0
Tires (casing for small car)	11.35	5.95	45.9	9.5
Inner tube (for small car)	2.55	1.10	10.3	1.7
Bicycle (coaster brake)	18.65	25.80	75.5	41.3
Paint (average house)	14.65	15.50	59.3	24.8
Camera	36.25	13.80	146.7	22.1
Drug and toilet articles	1.00	1.39	4.0	2.2
Tobacco	1.00	1.12	4.0	1.8

[1] Source of price information on each item is discussed in booklet following table. Prices are for typical qualities, models, and styles of 1914 and of today, and in many cases there have been great improvements in value not reflected in prices.

[2] These figures have been obtained by dividing 1914 prices by 24.7 cents per hour and today's prices by 62.4 cents per hour. The earnings per hour are from National Industrial Conference Board reports and represent the average for July, 1914, in the first case and the average for November, 1936, in the second.

ing from 4.65 per cent in the case of electric washing machines to 72.09 per cent in the case of electric-light bulbs. It must be noted here that the superior quality of the 1936 product over that of 1914 is not taken into account. All prices used, except in the case of automobiles, are at retail, so they reflect changes in marketing costs not revealed in wholesale prices.

Brief comments are made on each of the 20 items listed in Table 1 and it is shown that competition lowers prices. The following "conclusions" are quoted from the booklet:

(1) Technological development has made it possible for the United States to come closer to solving the problem of producing plenty than any other country in the world. Only by the development of mass-production methods, dependent upon technology, has it been possible to develop either the wide variety of goods available to American consumers or the immense quantities necessary to supply American needs.

(2) Technology is largely responsible for the high American wage level because it has made possible greater production per worker in most major industries than is found anywhere else in the world. Since wages and salaries represent more than two thirds of the nation's consumer purchasing power they play an important part in the American standard of living.

(3) Technology makes it possible to produce countless necessities and luxuries at lower prices than would be possible with less efficient methods.

(4) Improvement in value per dollar expended for machine-made products is constantly taking place as a result of scientific and technological development.

(5) Purchasing power of the consumer's income offers a truer indication of participation in the benefits of technological development than do either prices or wages by themselves.

(6) In 1936 the cost of living, according to the National Industrial Conference Board index, was 40 per cent higher than in 1914, but hourly wages of the average factory worker were two and a half times as high, and weekly wages were about twice as high in 1936 as in 1914.

(7) The general price level, as indicated by the United States Department of Commerce wholesale commodity price index, was 21 per cent higher in 1936 than in 1914, but ten out of twenty products in the manufacture of which there has been great technological improvement showed a decline in price.

(8) The consumer with the average factory worker's wage could buy these 20 widely used items with the earnings of 63 per cent fewer hours of work in 1936 than in 1914.

Superposition at Sea

THE INSTITUTE OF MARINE ENGINEERS

SO MUCH has recently been written about superposition power plants (see, for example, the September, 1936, issue of MECHANICAL ENGINEERING) that the application of the superposed boiler plant and high-pressure turbine to the driving of ships will excite wide interest. Such an installation was described by S. McEwen at a meeting on March 9, 1937, of The Institute of Marine Engineers in a paper entitled "The Loeffler Boiler Installation in the S.S. *Conte Rosso*."

The S.S. *Conte Rosso*, a passenger ship of 18,500 gross tonnage, completed her original acceptance trials in February, 1922. In March, 1936, the ship was generally overhauled and the superposed Loeffler boiler and new high-pressure turbines, which added 5000 shp and increased the speed by 1.5 knots, were installed.

The original boiler equipment included six double and two single Scotch marine boilers generating steam at 200 lb per sq in., superheated to 572 F. One single-ended boiler, which had a maximum capacity of 16,000 lb of steam per hr, was removed, and in its place a Loeffler marine boiler was installed capable of generating at normal rate 44,000 lb of steam per hr at a pressure of 1850 lb per sq in. and 890 F. The maximum rate provided for was 55,000 lb of steam per hr.

The ship, continues the author, has two propeller shafts; and the original turbine equipment, which is retained, consists of high- and low-pressure turbines with reversing stages coupled through gearing to each propeller shaft. The new turbine installation consists of two superpressure turbines, one for each propeller shaft, coupled thereto through new gearing forming an extension of the existing gearing. The two superpressure turbines work in series, that is, all the high-pressure steam from the Loeffler boiler is delivered to one turbine which exhausts at a pressure of 660 lb per sq in. to the second turbine. The exhaust from the second turbine passes through a steam-to-steam reheater and is delivered to the principal steam main at a pressure of 200 lb per sq in., and a temperature of 572 F. For emergency purposes a reducing valve is fitted to a branch of the superpressure steam main from the Loeffler boiler in order to provide a supply of steam at 200 lb per sq in. to the main and reversing turbines.

Figures given by the author compare the performances of the original and modified plants, assuming boiler efficiencies of 78 per cent for the Scotch marine boilers and 90 per cent for the Loeffler boiler. These show a total output of 17,800 shp for the original and 22,280 shp for the modified plant. The oil consumptions are 0.935 and 0.836 lb per shp per hr, respectively.

Information on instruments and automatic control is given in the paper. In conclusion the author offers the following general observations on the plant.

Since the superpressure plant was put into commission, several round trips have been made between Genoa and Shanghai,

so that there has been ample time to observe all details of performance, particularly those which are of major importance to the owners. Generally it can be stated that no difficulties whatever have been encountered which could be attributed to the use of high-pressure high-temperature steam; the power developed by the superpressure sets is greater than that which was guaranteed, with the result that the guaranteed increase of speed of the ship has been exceeded by one half knot. The acceptance tests have proved that all the performance guarantees had been fulfilled.

After continued operation a thorough examination of the combustion chamber disclosed a most satisfactory condition. There were no ash or coke deposits on the heating surface nor could any deterioration of the tubes be detected. The condition of the boiler was such as to impress the operating staff most favorably.

Notwithstanding the use of a relatively small evaporating drum and the high degree of salt concentration obtained on occasions, no trouble whatever has been experienced due to carry-over of salts with the steam.

The installation of one Loeffler boiler in the space occupied by one single Scotch marine boiler has increased the steaming capacity of the boiler plant by 13.5 per cent; it has increased the power developed about 30 per cent, while the fuel-oil consumption per shaft horsepower for the whole power plant both old and new together has been reduced by 10 per cent.

Cast-Iron Graphitic Corrosion

METALS AND ALLOYS

DISINTEGRATION of cast iron exposed to certain types of corrosive environments, known as graphitization, results when the ferrite of the iron is removed from the affected zones leaving a black porous structure which may retain the form of the original metal but be devoid of its strength. This porous residual material, according to W. A. Wesley, H. R. Copson, and F. L. LaQue, in an article entitled "Some Consequences of Graphitic Corrosion of Cast Iron," to be found in the December, 1936, issue of *Metals and Alloys*, is rich in carbides and usually contains a considerable amount of free iron. It is generally agreed, they continue, that the contact between ferrite and the graphite in the cast-iron structure leads to electrochemical action, the ferrite acting as an anode and dissolving, and the graphite as cathode.

Cast iron occasionally has a corrosion resistance superior to other materials when the layer of graphite is sufficiently plugged with insoluble products to be protective. However, in some environments the products of corrosion do not deposit in the pores and the galvanic effect of contact of the base with a large area of graphite may cause more rapid corrosion than will be found with steel. An instance is cited by the authors where a corrosion of some specimens of cast iron exhibited a corrosion rate of at least 2500 mg per sq dm per day while mild-steel specimens similarly exposed were corroded at the rate of 60 mg per sq dm per day, or at about one fortieth of the rate of the cast iron. A third condition may exist when one part of a cast-iron apparatus bears a graphitized coating and another iron part in galvanic contact with it remains uncoated, in which case the rate of the corrosion of the uncoated part may be greatly accelerated. As an example the authors cite the cast-iron centrifugal-pump case with its cast-iron impeller.

Examples of the cathodic behavior of graphite are quoted by the authors and laboratory tests to illustrate the importance of the rôle which a graphite coating may play in the corrosion of underlying metal or of clean metal with which it is in galvanic contact are described. Other tests are mentioned in which austenitic cast iron (Ni-Resist) and graphite-coated cast-iron electrodes were employed with results that indicated that there is little danger of an accelerated corrosion rate for the Ni-Resist. In other tests it was indicated that in the galvanic corrosion of clean Ni-Resist coupled with graphite-coated Ni-Resist, the actual magnitude of the galvanic corrosion depends on the area, thickness, and porosity of the graphite coating.

In discussing the application of the data assembled the authors state that practical means for reducing the types of corrosion discussed are suggested. It is quite often true that the casing of cast-iron centrifugal pumps outlasts the impeller and it is common practice to install new cast-iron impellers in old cast-iron casings. If the casing has suffered graphitic corrosion the rate of corrosion of the new impeller may be accelerated appreciably by its galvanic contact with the more noble graphite layer on the casing. This galvanic effect may serve to account for the occasional complaint that replacement impellers do not last as long as the original impellers in cast-iron pumps. The results of this study indicate that such complaints may be avoided by using austenitic cast-iron impellers for replacement, since the potential between Ni-Resist and a graphite-coated casing will either be of negligible magnitude, or in a direction to protect the former.

Similarly, where erosion prevents the accumulation of graphite on the impellers, but not on the casing, it should be good practice to use Ni-Resist impellers in the original installation so as to avoid galvanic corrosion between impeller and graphitized casing.

It is possible to avoid graphitic corrosion in many cases by refining the grain, reducing the graphite particle size, and increasing the soundness of cast iron through the use of relatively small amounts of alloying elements. Such improvement in the structure of the iron tends to reduce the depth to which corrosion can penetrate readily, and indirectly limits the extent of graphitic corrosion.

Specific Power Factor

THE ENGINEERING JOURNAL

SPEAKING before the Montreal Branch of The Engineering Institute of Canada, A. I. Lipetz, member, A.S.M.E., in charge of research of the American Locomotive Company, presented a survey of "Recent Developments in European Railroad Motive Power," published in *The Engineering Journal* for February, 1937. A portion of Mr. Lipetz's paper in which he discussed what he termed the "specific power factor" of the locomotive is presented in what follows.

After reviewing certain achievements in the field of speed and power on this continent and in Europe, Mr. Lipetz said that in order to achieve these remarkable results not only new designs and improvements of power plants became necessary, but new ideas in the construction of the equipment had to be adopted. This led to the practice of lightening both locomotive and cars, and established a tendency to what may be called "concentration of power." With the increase in speed the power per unit of weight had to go up. When the Diesel engine further proved its advantage as regards thermal efficiency, there was a great temptation to adopt high-speed Diesel-electric trains. However, the limitation of the Diesel engine, even the high-speed Diesel, with respect to its power-weight ratio, soon became apparent, and, therefore, if the power plant was heavy, the chassis of the vehicle had to be light. Thus, new metals,

TABLE 2

SPECIFIC POWER FACTORS OF STEAM AND DIESEL LOCOMOTIVES AND TRAINS

Item	Locomotives	Cylinder or b.h.p.	Rail h.p.	Weight, Half-working Order, tons	Specific Power Factor
	Steam Locomotives				
1	Reichsbahn 4-6-2, 4-cyl., comp. superheat, No. 02010	2230	2007	169.4	11.9
2	P.O.-Midi 4-6-2, 4-cyl., comp. superheat, No. 3579 (1912)	1873	1586	152.0	10.4
3	Rebuilt P.O.-Midi 4-6-2, 4-cyl., comp. superheat, No. 231-726 (1934)	....	3500	182.0	19.2
4	Nord 2-8-2, tank with Cossart piston valves (1935)	....	2330	126.1	18.4
5	P.L.M. rebuilt 4-6-2 locos., 4-cyl., superheat (1932)	....	3000	174.0	17.3
6	Nord 4-6-4, multiple reciprocating engines, individual drive (under construction)	....	2400	184.6	13.2
	Steam Turbine Locomotives				
11	L.M.S., 4-6-2, direct drive, gear transmission	....	2500	171.0	14.7
12	U.P., 4-6-6-4 + 4-6-6-4, electric transmission (under construction)	5000	3750	480.0	7.3
13	P.L.M.-Creusot, 4-6-4 locomotive, direct drive (under construction)	2625	2460	191.6	12.8
	Diesel Locomotives and Trains				
21	600 b.h.p. switching, U.S.A.*	600	450	68–110	4.3–6.7
22	Canadian National 4-8-2 + 2-8-4*	2660	1995	162.5	6.1
23	U.S.S.R., 4-8-2 + 2-8-4*	2400	1800	265.0	6.8
24	Busch-Sulzer, 1-B + B-1*	2000	1500	173.0	8.5
25	Ingersoll-Rand, Illinois Central*	1800	1350	130.0	10.3
26	B-B + B-B, Santa Fe*	3600	2700	241.0	11.2
27	P.L.M., 4,000 h.p. (under construction)*	4000	3000	246.4	12.2
28	"Flying Hamburger," Diesel-hydraulic, 3 units	1200	900	77.0	11.7
29	"City of San Francisco" (2 locomotive units)*	2400	1800	195.7	9.2
30	Denver "Zephyr" (2 locomotive units)*	3000	2250	213.0	10.5

*With electric transmission.

like aluminum, high-tensile or stainless steel, and new methods of construction, like welding, had to be employed. This led to the light weight Diesel-electric train, introduced first in Germany, and then in the United States and in other European countries. If the Diesel could not meet the power of the steam locomotive, it was necessary to make the vehicle lighter to achieve the same results.

How was the steam locomotive to meet this new challenge? The first of its past rivals had been the electric locomotive, which did not turn out to be so formidable as expected. Then came the switching Diesel-electric locomotive, very modest, with rather limited pretensions; this rival did not prove to be so important either. The latest rival, though, seemed to be serious, and the situation was met by "concentration of power."

This was not new for the steam locomotive, especially in Europe. It was already customary in some countries of Europe to evaluate the perfection of a design of a locomotive by its "quality number." This was arbitrarily expressed by a ratio, the numerator of which was the sum of the water-evaporating heating surface of the boiler and 80 per cent of the outside superheating surface, the denominator being the weight of the locomotive in working order (without tender). A more significant figure would be the ratio of the actual power, as determined by tests, to the weight of the locomotive with half-loaded tender—this in order to make it comparable to the Diesel locomotive, which has no tender, but carries a supply of fuel and water. For weight calculation, the supply tanks of Diesel locomotives and trains are assumed to be always full. This ratio could be called "power concentration factor," or still better "specific power factor."

Table 2 gives comparative figures for the specific power factors of some modern steam and Diesel locomotives and trains. The figures are given in rail horsepower per ton of weight. The horsepower is in British units (550 ft-lb per sec); the weight is in American short tons (2000 lb); the weight of the tender is with half supply of water and fuel; the rail power for steam locomotives is taken from test, and when this is not available, is figured from the indicated horsepower from test, multiplied by the mechanical efficiency of the engine drive, which is assumed to be 90 per cent. For Diesel-electric locomotives, for which usually the brake horsepower of the oil engine is known, the rail horsepower is figured on the efficiency of the whole transmission (electric, gear, and axle) being 75 per cent. The same applies to power cars of Diesel-electric trains, and for the latter, if the power car has seats for passengers, an adjustment for this part of the weight is made. For trains and locomotives with mechanical transmission the efficiency is assumed to be 92 per cent. For turbine locomotives with direct drive by precision gears the mechanical efficiency is taken equal to 94 per cent; for turbine locomotives with electric transmission, to 75 per cent.

When multiplied by the ratio of the weight of the locomotive with half-loaded tender to the weight of the train, the specific power factor represents the power input per ton of train weight and is a good criterion for the ability of the locomotive to accelerate the train.

Machine-Control Calculator

MACHINERY (LONDON)

LAST month, in an abstract on color control for machines, an indicating device was referred to by means of which the operator of a machine tool knows how to set the control levers of his machine in order to procure the speeds and feeds best suited to the work on which the machine is engaged. In *Machinery* (London) for March 18, 1937, details of a device for performing the calculations and providing the indications necessary for proper selection are described. The device described is that of Murray Colour Controls, Ltd., and the principle of operation is illustrated in Figs. 1 and 2.

Referring to Fig. 1, which is a calculator, the outer casing *A* is provided with two apertures, *B* and *C*. In aperture *B* appear figures marked on the outer surface of a sleeve *D*, and for each

setting a circular hole in the sleeve is brought into line with the aperture C. Through this hole can be seen one of a series of numbers marked on the surface of one of the small drums E. The number in aperture B, for example, may indicate the diameter of the work or cutter and that in aperture C the corresponding cutting speed in feet per minute.

The spindle speed in revolutions per minute is shown in a third aperture in F, the number being marked on the enlarged head of the spindle G.

In practice knurled disk H, to which D is attached, is rotated to bring a number corresponding to the diameter of the cutter or work in aperture B. This movement, transmitted through

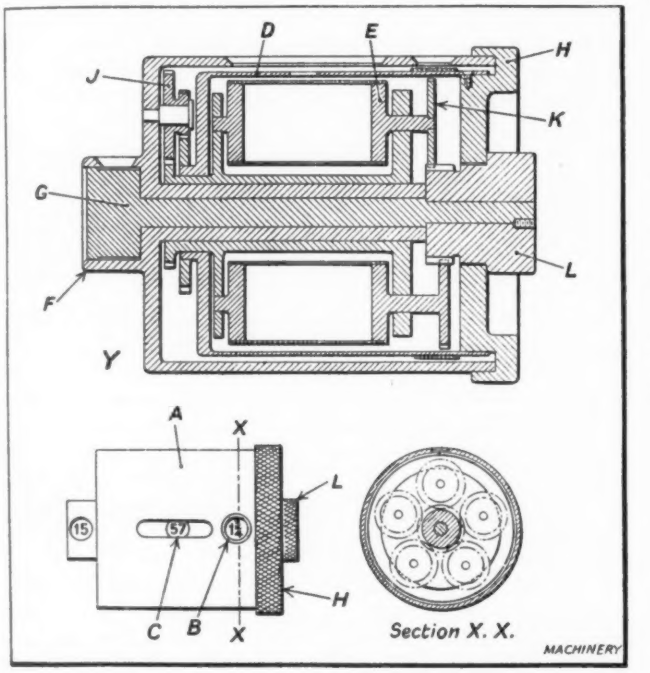


FIG. 1 CALCULATOR

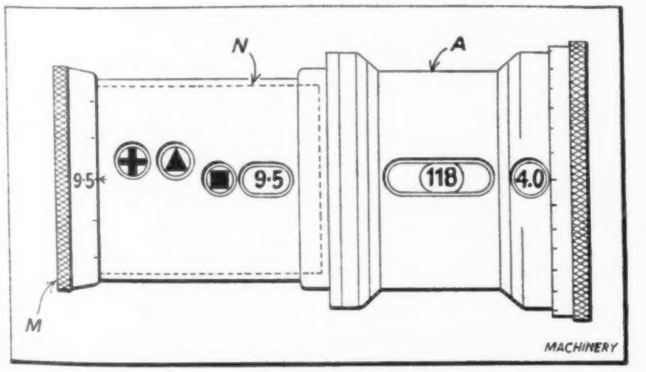


FIG. 2 CALCULATOR AND INDICATOR

planetary gearing, causes the number supporting the small drums to rotate about the axis of the spindle G, thus carrying the drum collectively with it. Gears K, meanwhile, move idly around the pinion integral with the knurled knob L. The knob is then turned by hand, and through the pinion and gears K, causes the drums to rotate about their own axis until a figure indicating the desired cutting speed appears in the hole in sleeve D, opposite aperture C. The device is thus set so that the correct spindle speed is shown at F. The number of holes in sleeve D, within the length of aperture C, and the number of figures around the periphery of each small drum can be arranged to suit the particular purpose for which the calculator is designed.

Fig. 2 shows a calculator in conjunction with an indicator. Knob L is replaced by knurled disk M, graduated, for example, with figures indicating the spindle speed in revolutions per minute. This disk is connected to both the central spindle G and an internal shutter sleeve N, on which symbols relating to the positions of the control levers and numbers indicating the feed rates are inscribed.

The calculators can be used either on the machine, as described last month, or away from it, and can be adapted to new machines or those already in use.

Magnesium Aircraft Alloys

THE METAL INDUSTRY

CLOSELY packed with information on magnesium alloys for aircraft, a paper on that subject, presented to the Royal Aeronautical Society by C. H. Desch, superintendent of the Metallurgical Department of the National Physical Laboratory, is to be found in the Jan. 29, 1937, issue of *The Metal Industry*.

Dr. Desch prefaces his paper by recounting some of the disappointments that have attended the development of beryllium which appeared to offer advantages as a light metal for aircraft use, although attention is now being directed to alloys with aluminum.

Magnesium, which is too weak a metal to be used in the unalloyed state, can be alloyed with only a relatively few metals, and of these only aluminum and cadmium are suitable for alloying in more than quite small quantities. Calcium, cerium, zinc, nickel, cobalt, and manganese, which can only form solid solutions to a very limited extent, have, on the other hand, been useful in small quantities.

Aluminum alloys are easy to cast, and ingots and castings do not suffer from sponginess. Shrinkage in the mold is nearly the same as that of common castings of aluminum. A flux of mixtures of chlorides and fluorides is used to protect the surface against oxidation, and a protective atmosphere must be used during pouring and annealing. Comparatively large gates and risers are necessary, but the scrap may be remelted with very little loss. A table of the physical properties of cast and heat-treated alloys forms a part of the paper, and the author discusses the heat-treatment, die casting, and X-ray examination of magnesium castings.

The crystal structure of magnesium is hexagonal, and this is a source of difficulty in working the metal. The yield point in tension differs from that in compression in a forging made under normal conditions. It is even possible to have ductility in one direction and brittleness in another. This difficulty is overcome by making the crystal grains as small as possible by casting the ingot at high temperature. In subsequent working the object is to check the "preferred orientation" which may be controlled by taking advantage of three factors. When the temperature of deformation is above 225 C and all the malleability due to the basal plane is exhausted, slip occurs along other planes. Second, if the metal can be squeezed first in one direction and then in another, a much greater degree of deformation is possible than in a simple operation, such as rolling. Lastly, the time factor has a very great influence.

Magnesium and its alloys may be deformed slowly when quick working at the same temperature and with the same stresses would cause cracking. Extension and pressing between hot dies are successfully applied in practice. Rolling

gives a structure with highly directional properties. Rolling at a very slow speed allows of much more change of section without cracking than does the practice usual with other metals, and mills run at a very low speed are used industrially. At the N.P.L. an experimental mill has been installed, having rolls 14 in. long and 8 in. diameter, with gearing allowing the speed to be reduced to 2.5 ft per min, and with a range of variation up to 15 ft per min. The rolls are uniformly heated by electrical-resistance mats placed in contact with them, and giving a temperature of 200 C conveniently.

Sections of the paper on sheet rolling, wrought alloys, and alloys at high temperatures are too detailed for abstracting within space allowances. The paper concludes with comments on corrosion problems and abrasion difficulties, which are not abstracted here.

Heating Water by the Sun

UNIVERSITY OF CALIFORNIA

FROM the Agricultural Experiment Station of the University of California, Berkeley, Calif., comes a 64-page bulletin No. 602 by F. A. Brooks entitled "Solar Energy and Its Use for Heating Water in California." Under three general subject headings the bulletin discusses the availability of solar energy, the solar water heater, and the use and construction of solar water-heater systems. While the last two of these subjects will be of greatest interest to home owners in California who contemplate the installation and use of solar water heaters (several thousand are now in use, says the bulletin) the first section on the availability of solar energy may be of greatest interest to engineers seeking information on solar energy.

Starting with the energy distribution with respect to wave length in the normal solar spectrum outside the atmosphere, solar-energy curves are shown for solar altitudes of 65, 30, 19.3, and 11.3 deg after average depletion due to scattering dry dust and gases of the atmosphere. Tables and curves give values for solar radiation at certain California localities in terms of heat units per square foot per unit of time. Climatological data for 31 localities throughout California over a ten-year period give average number of days of sunshine, frost dates, and seasonal temperatures. Another table gives the solar-energy absorptivity and surface emissivity, at ordinary temperatures, of standard materials and of such other materials as meteorological formations, ground and pavements, vegetation, building and roofing materials, paints, and metals. The effect of angle of incidence on the amount of light transmitted by glass and absorbed by a black surface is also tabulated.

The remainder of the bulletin discusses the solar water heater, with illustrations of various types and results of experimental investigations, and the use and construction of solar water-heater systems, several of which are illustrated by diagrams. There is a brief note on the initial cost and carrying charges. The following general summary concludes the bulletin.

Enclosed 30-gallon hot-water boilers with glass covers can be used as solar heaters without pipe-absorber coils and will furnish two or three hot showers per tank in the late afternoon or evening of bright sunshiny days. These tank absorbers do not keep their high temperatures overnight and are not a satisfactory means of obtaining hot water for washing clothes.

The glass area of the ordinary pipe-coil absorber should be about as large in square feet as the number of gallons of storage-tank capacity. The $^3/_4$-in. pipes are conveniently spaced about $2^3/_4$ or 3 in. center to center and usually should be arranged in parallel circuits to avoid excessive temperature rise. The length of single pipe of about 70 to 100 ft when the absorber discharges into the storage tank about 7 ft above the center of the absorber gives over 30 F temperature rise, which is adequate. When the tank inlet is lower, the single-pipe length should be reduced in proportion.

The insulated storage tank used with regular pipe-coil absorbers should have a capacity equal to the whole day's hot-water demand because about half of the hot water is often used after sunset and about half is often needed early in the morning before the sunshine has had time to heat much water.

To insure a constant supply of hot water regardless of the weather, the hot outlet pipe from the solar-heater storage tank can be connected to the cold inlet of an automatic auxiliary heater. Then if the solar-heated water is not up to thermostat-control temperature the automatic heater will operate to raise the temperature to the desired point. When there is good sunshine the water entering the automatic heater whenever a faucet is opened will already be hot enough, and the auxiliary heater need not operate. With such a combination system the housewife will never be bothered by lukewarm water, yet will save heating expense when the sun shines.

Soft-Copper Gaskets

CHEMICAL AND METALLURGICAL ENGINEERING

HIGH-GRADE copper, 99+ per cent chemically pure, is generally accepted as the best gasket material for sealing high-pressure containers, says William L. Edwards, of the Bureau of Chemistry and Soils, U. S. Department of Agriculture in an article entitled "Designing Soft-Copper Gaskets for High-Pressure Equipment" in the March, 1937, issue of *Chemical and Metallurgical Engineering*.

In general, Mr. Edwards continues, gaskets may be classified with reference to joint construction as confined, unconfined, and partly confined, and further as those with constant bearing area and those whose bearing area increases as the gasket is compressed. These terms are made clear by a study of the types shown in Fig. 3.

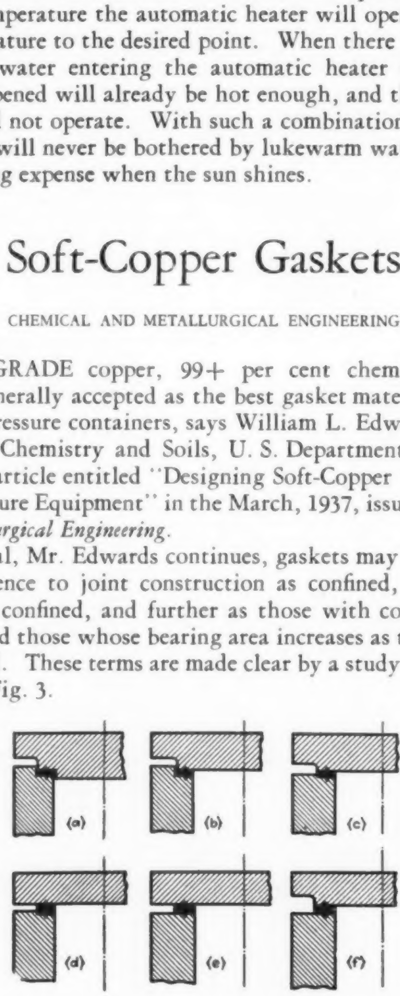


FIG. 3 TYPES OF HIGH-PRESSURE GASKET JOINTS WITH THE GASKET CONFINED IN (*a*), PARTLY CONFINED IN (*b*), (*c*), AND (*d*) AND UNCONFINED IN (*e*) AND (*f*); JOINTS (*a*), (*b*), (*c*), AND (*f*) HAVE CONSTANT BEARING AREA, JOINTS (*d*) AND (*e*) INCREASING BEARING AREA

The design of flat copper gaskets should be based on the maximum unit internal pressure at which the container is to be tested. A test pressure of one and one half times the working pressure is ample for pressures of 5000 to 10,000 lb per sq in.; and above 10,000 lb a test pressure of 5000 lb per sq in. in excess of the working pressure is sufficient. For purposes of design it is necessary to know the total initial load on the gasket, what residual unit gasket pressure should be maintained, and what

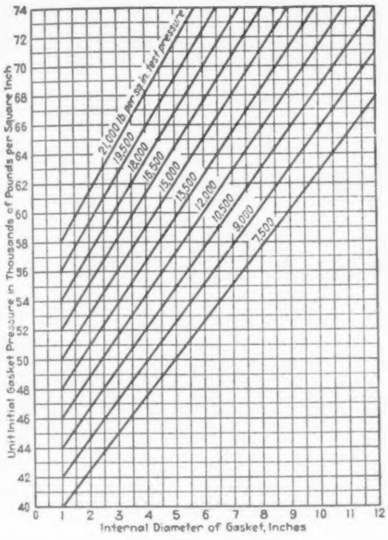


FIG. 4 INITIAL GASKET PRESSURES FOR VARIOUS SIZES OF GASKET AT VARIOUS TEST PRESSURES

initial unit gasket pressure should be used. As none of these can be exactly determined, certain assumptions, based on experiment and experience, must be made.

The total initial load consists of the sum of the total maximum internal load and the total residual gasket pressure. The first of these is the product of the maximum internal unit pressure and the area over which this pressure acts, and depends on the type of closure and design of the head. If the head is designed so that the joint is some distance within the bolt circle, deflections of the head from external pressure before and internal pressure after the internal load is applied may result in a leak. When the external pressure is directly over the gasket, as may be the case in certain designs shown in the article, there is little deflection over the gasket and the pressure area is the port area of the gasket.

Residual unit gasket pressure has been investigated with results that indicate that a value equal to 1.25 times the maximum unit internal pressure is sufficient to produce a pressure-tight joint if the initial gasket pressure has produced a flow of the copper gasket.

Based upon information gained through experiment, experience, and knowledge of actual tests, the chart shown in Fig. 4 has been constructed as a guide for selecting initial unit gasket pressures for different internal diameters of gaskets and for various test pressures. By using the internal unit gasket pressures obtained from the chart, says Mr. Edwards, the necessary flow of copper can be produced without deformation of the metal contact surfaces and the total load required to make the joint pressure-tight can be kept at a minimum.

As an empirical rule the thickness of the partly confined gasket should be one fifth of its width with a maximum thickness of $^1/_8$ in. For the confined type of joint the thickness of the gasket is not important.

Mr. Edwards gives the following formulas for designing flat copper gaskets

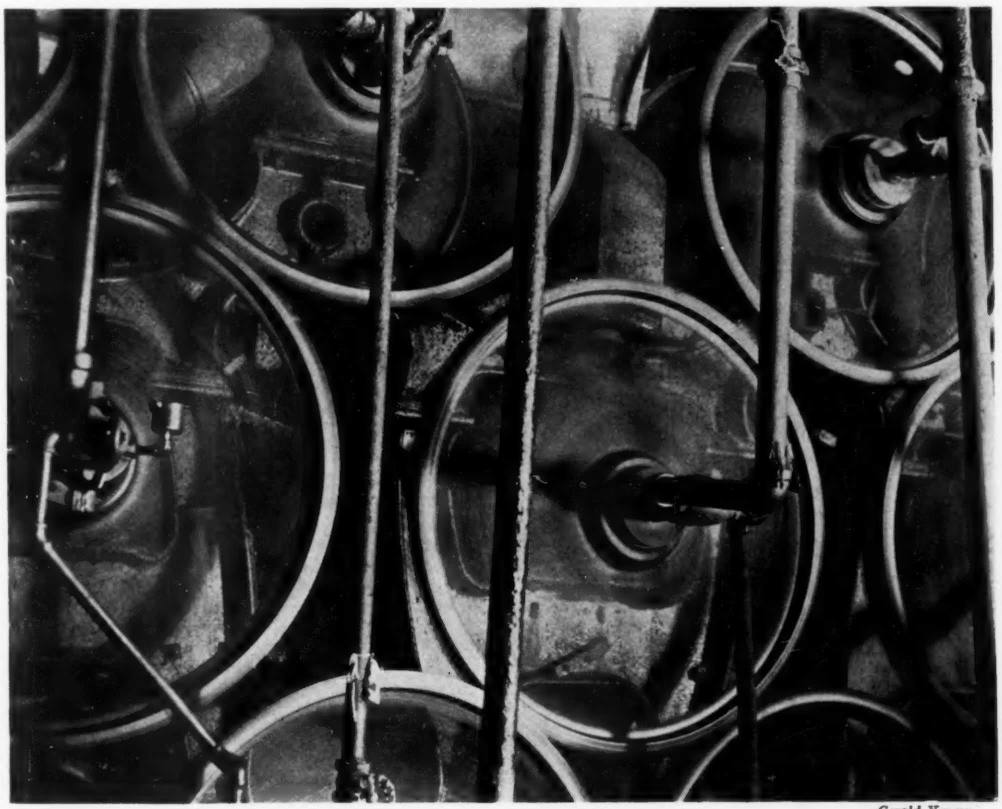
$$L = \frac{\pi D^2}{4} P_T + 1.25\, P_T a = P_G a$$

$$a = \frac{\pi D^2}{4} P_T/(P_G - 1.25\, P_T)$$

in which

L = total initial load on the gasket, lb
D = internal diameter of gasket, in.
P_T = maximum initial unit pressure (or test pressure), lb per sq in.
P_G = initial unit gasket pressure, lb per sq in., from Fig. 4
a = area of gasket, sq in.

In these formulas the minimum width is assumed to be $^1/_8$ in.; hence if the calculated width is less, a gasket $^1/_8$ in. wide is used.



Gerald Young

Encouraging Research in Engineering Education

(*Continued from page 354*)

administrator is not an easy one, since approximately 30 per cent of the high-school graduates enter college, while the remaining 70 per cent receive no further formal education.

PROFESSIONAL GROUPS SHOULD DEFINITELY PLAN HIGH-SCHOOL COURSES

The only feasible solution to the problem of obtaining a proper pre-engineering education is for the national engineering group to specify definitely a rigorous intellectual preprofessional training to be offered by the high schools. Some excellent groundwork has been done in the high schools by the American Engineering Council, the Engineering Council for Professional Development, and the Society for Promotion of Engineering Education. This, however, has been in the field of orientation of students, rather than an attempt to improve the material offered to them, and the study habits of high-school students.

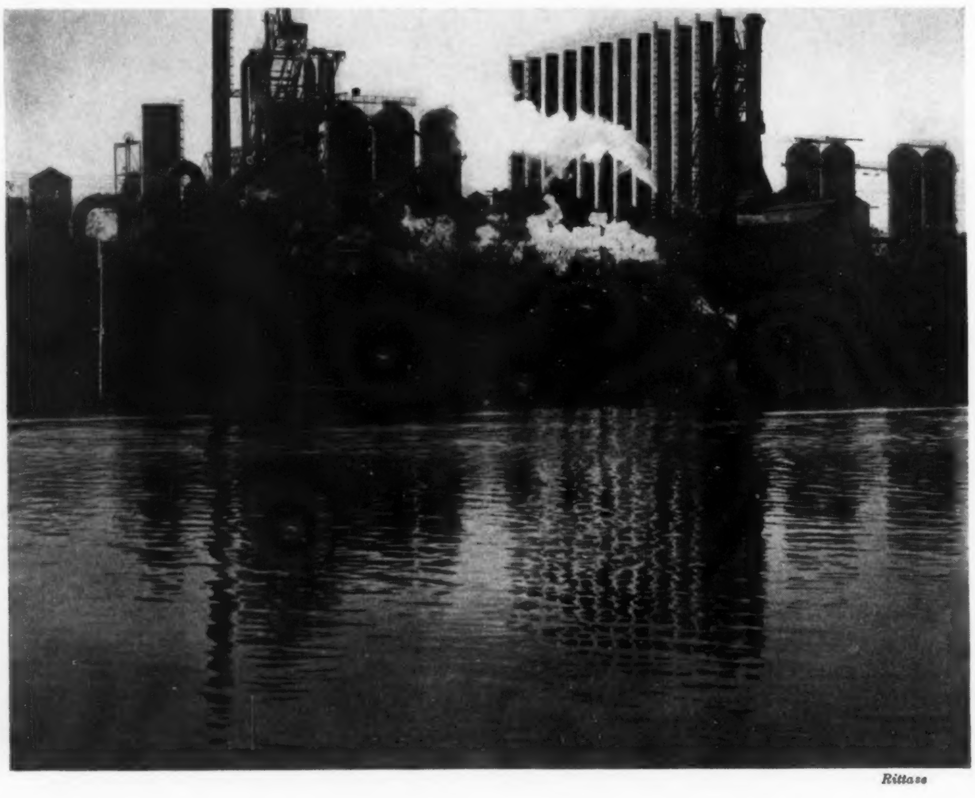
This apparent tendency in the high schools for a constant weakening of the intellectual standards, with the failure of the formation of good study habits on the part of the student, is a question that should interest not only members of our own profession but also those of the legal and medical professions. The problem, is the most urgent one that faces professional education today.

Perhaps, one step toward the solution of this high-school training problem would be the appointment of a National Committee on High-School Training for the Professions, whose members would be appointed by the national professional groups in engineering, medicine, and law. Their duties would be, not only to provide the high schools with suitable published material for orientation in all of the professions, but also to specify rigidly the minimum intellectual requirements for a definitely labeled "professional option" in the high schools, leading to later professional training in the selected college of engineering, medicine, or law. This question is of sufficient importance to warrant the careful thought of all members of our profession whether they are interested in the high schools as engineering educators or more directly as parents of boys who now are expecting to enter professional training.

The Problem of Investment

(*Continued from page 362*)

The concluding topic raised by the study is the question: "What can be done to help the investor in meeting his problem?" Certain things can be done and in fact much has recently been done in the form of legislation. Improved "Blue Sky Laws" among the states and the Federal Securities Act and the Securities Exchange Act offer substantial assistance and protection. In particular those features of the law calling for a wider and more complete revelation of corporate information and restraints on the opportunity for exploitation by insiders should prove a valuable aid to uninformed investors. More complete and standardized accounting methods and an extension of the practice of having minority representation on boards of directors are steps that may be taken. But no protective legislation and no number of government agencies can be made a substitute for the eternal vigilance and informed judgment of the individual himself. All the influences and forces herein mentioned must be by him considered. Moreover, and this is the most disheartening item of all, the greatest risks are hidden risks—hidden both in the as yet unopened future and in the unpredictable acts of those clothed with wide discretionary powers under our new venture in government. "Some of the most formidable problems and risks confronting the investor today are those arising from: taxation, inflation, new legislation, contract repudiation, and constitutional interpretation."



Rittase

A.S.M.E. BOILER CODE

Revisions and Addenda to Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets []. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-3. Revise to read:

P-3. Open-hearth steel pipe or steel tubing in accordance with Specifications S-18 for Welded and Seamless Steel Pipe, S-32 FOR ELECTRIC-RESISTANCE WELDED STEEL AND OPEN-HEARTH IRON BOILER TUBES, or S-17 for Lapwelded and Seamless Steel and Lapwelded Iron Boiler Tubes, may be used for a boiler drum or other pressure part, etc.

PAR. P-21*a*. Revise to read:

a Boiler generating tubes, expanded into tube seats, shall comply with Specifications S-17 for Lapwelded and Seamless Steel and Lapwelded Iron Boiler Tubes, S-32 FOR ELECTRIC-RESISTANCE WELDED STEEL AND OPEN-HEARTH IRON BOILER TUBES, or S-22 for Seamless Copper Boiler Tubes.

PAR. P-101. Revise first section to read:

Drums, [or] shells OR OTHER CYLINDRICAL PRESSURE PARTS [of] AND NONCYLINDRICAL PRESSURE PARTS, EXCEPT STAYS OR BRACES, AS SPECIFIED IN PAR. P-114, may be fabricated by means of fusion welding provided the construction is in accordance with the requirements for material and design as required by this code and the fusion welding process used conforms to the following specifications.

PAR. P-102*a*. Change paragraph title to read: Test Plates [for Longitudinal Joints]. Add the words "and thickness" after the word "specifications" in the third line.

PAR. P-102*b*. Delete the title reading: "Test Plates for Circumferential Joints." Add the following:

When noncylindrical pressure parts are not integral with the drum or shell, the two test plates, of a thickness not less than that of the parts, shall be provided.

When there are several pressure parts being welded in succession, on any one order, the plate thicknesses of which fall within a range of $^1/_4$ in., with diameters differing not more than 6 in., and of the same grade of material, two test plates shall be furnished for each 50 linear feet, or fraction thereof, of welded joints.

PARS. P-102*i* AND U-68*i*. In the first section, revise the second sentence to read:

In case the wall thickness exceeds $5^1/_4$ [$4^1/_4$] in., and until such a time as evidence is submitted to the Boiler Code Committee that greater thicknesses can be commercially examined, the joints shall be stress relieved and then radiographed when the thickness of the metal deposited in the weld is $5^1/_4$ [$4^1/_4$] in.

Insert the following as the second section:

All welded joints to be radiographed shall be prepared as follows: The weld reinforcements on both the inside and outside shall be ground, chipped and ground, or suitably machined to remove the irregularities of the weld surface so that it merges smoothly into the plate surface. The finished surface of the reinforcement may have a crown of uniform amount not to exceed approximately $^1/_{16}$ in.

Replace (1*a*) and (2*a*) by the following:

(1*a*) A penetrameter of the type shown in Fig. P-4 shall be placed at each end of the exposed portion of the weld with the penetrameter parallel to the weld and at least $^1/_4$ in. from the edge of the weld. Two ranges of penetrameters shall be available; these shall be stepped as follows: 0.005 in. to 0.04 in. for plate thicknesses up to 2 in., and 0.04 to 0.105 in. for plate thicknesses from 2 in. to $5^1/_4$ in., as shown in Fig. P-4. In every case the thickness gages or penetrameters should be so placed that the thin edge of the gage will be adjacent to the end of the exposed section of the weld.

FIGS. P-4 AND U-12. Omit illustrations (*b*) and the letters "(*a*)." Revise the last step in (*a*) by changing "0.09" to "0.105" and "$4^1/_4$" to "$5^1/_4$."

PAR. P-105*a*. Revise first sentence to read:

Longitudinal, [and] circumferential, AND OTHER joints UNITING THE PLATES OF THE DRUM, SHELL, OR OTHER PRESSURE PARTS, EXCEPT AS PROVIDED FOR IN PARS. P-186 AND P-268, shall be of the double-welded butt type, etc.

PAR. P-108*a*. Revise first sentence to read:

All [fusion-welded] PRESSURE PARTS [drums or shells] of power boilers, FUSION WELDED UNDER THE PROVISIONS OF PARS. P-101 TO P-114 INCLUSIVE, shall be stress relieved.

PAR. P-108*c*. Revise to read:

(2) Heating a [complete] section [of the drum], SUCH AS A head or course IN A DRUM, containing the part or parts to be stress-relieved before attachment to other sections [of the drum].

PAR. P-109*a*. Revise first sentence to read:

All fusion-welded drums AND OTHER PRESSURE PARTS shall be subjected to the hydrostatic pressure as prescribed in Par. P-329, and while subject to this pressure ALL BUTT WELDED JOINTS shall be given a thorough hammer or impact test.

PAR. P-109*b*. Revise to read:

b Following this test, the pressure OF WELDED DRUMS shall be raised to not less than twice the maximum allowable working pressure and MAINTAINED [held there] a sufficient length of time to enable an inspection to be made of all joints and connections. ON OTHER PRESSURE PARTS IT SHALL BE MAINTAINED AT NOT LESS THAN $1^1/_2$ TIMES THE MAXIMUM ALLOWABLE WORKING PRESSURE A SUFFICIENT LENGTH OF TIME TO PERMIT COMPLETE INSPECTION. THE HYDROSTATIC TEST PRESSURE OF THE COMPLETED UNIT SHOULD NOT EXCEED THAT PROVIDED FOR IN PAR. P-329.

PAR. P-109*d*. Omit the fifth sentence.

PAR. P-109*e*. Revise to read:

e DRUMS OR parts [drums] shall be stress relieved after any welding repairs have been made.

PAR. P-109*f*. Revise first sentence to read:

After repairs have been made, the PART [drum] shall again be tested in the regular way, etc.

PAR. P-112. Insert the following as a new paragraph:

P-112. *Welded Pipe Connections.* *a* When not in contact with furnace gases, pipe or tube connections for steam not exceeding 14 in. in outside diameter or for water not exceeding 6 in. pipe size, may be fusion welded without radiographic examination of the circumferential welds provided the welding complies otherwise with the requirements of Pars. P-101 to P-109. The materials used shall comply with the requirements of Par. P-103.

(*1*) The diameter and thickness of the pipe or tube for the test weld shall be the maximum to be used in construction, except that the size of the pipe or tube used in the test shall not be less than 4 in. standard weight and need not be more than 8 in. double extra heavy.

(*2*) For each process an operator need be qualified only for the types of joints and positions that he will encounter in construction. The positions of the pipe or tube within a range of 45 deg for the test weld shall be either horizontal fixed position or vertical fixed position, or both. Wherever conditions for welding in actual construction are such that it may be difficult, because of inaccessi-

bility, to make a sound welded joint, the operator shall also make one sample joint simulating the actual construction.

(3) From each test weld shall be taken the following test specimens which shall be prepared for testing as shown in the figures referred to: Two reduced-section tensile specimens, Fig. P-7A;[1] two free-bend specimens, Fig. P-7B;[2] two root-break specimens (not required where backing-up strip is used), Fig. P-7C;[3] two side-break specimens, Fig. P-7D;[4] two nick-break specimens, Fig. P-7E;[5] two etch specimens (required only when backing-up strip is used). No two specimens of the same type shall be removed adjacent to each other. For horizontal fixed position welds, the specimens shall be removed from the bottom segment of the pipe.

(4) The tensile strength of reduced-section specimens shall be not less than the minimum of the specified tensile range of the material used. The free-bend specimens shall meet the requirements of Par. P-102*f*. The root-break specimens shall be tested as shown in Fig. P-7F[6] and the surface examined for lack of soundness. The side-break specimens shall be tested as shown in Fig. P-7G[7] and the surface of the fracture shall be examined for lack of fusion. The nick-break specimens shall be tested as shown in Fig. P-7H[8] and the surface examined for lack of soundness. The specimens shall show soundness equivalent of that required of test plates under Par. P-102 and no lack of fusion. The etch specimens shall be prepared for testing as follows: The two cross-sectional surfaces of the welded-joint specimen shall be polished to bright smooth surfaces which may be accomplished by filing and polishing with emery cloth and should be completed with the use of emery cloth of 00 grade. If the specimens have been removed by flame cutting they shall be machined, ground or filed to a smooth surface by the removal of not less than 1/8 in. of material below the flame cut surface and they shall then be polished as above. The specimens shall then be etched in a boiling solution of equal parts of hydrochloric acid and water for a sufficient period of time to reveal all lack of soundness that might exist at the cross-sectional surfaces of the specimen.

(5) Records shall be kept of test result.

Par. P-113. Insert the following:

P-113. Superheater tubes complying with Specification S-17 and not exceeding 2 1/2 in. diameter may be fusion-welded to tubular manifolds or headers without being expanded. The welds shall be strength welds similar to Fig. P-7*b*, and shall be stress relieved. Radiographic examination and hammer tests of the welds may be omitted. A hydrostatic test shall be made at twice the working pressure subject to any necessary modifications due to temperature requirements in accordance with Table P-8.

Par. P-114. Insert the following:

P-114. The front and back sheets of staybolted box-type headers for water-tube boilers may be joined together by fusion welding as indicated in Fig. P-7J,[9] provided the flat portion in the trough of the header does not exceed 90 per cent of the allowable staybolt pitch permitted by Par. P-199. The joint shall be radiographed and the welded structure stress relieved.

Par. P-186*c*. Delete the last sentence. Add the following:

In vertical tubular and firebox types of boilers the flanged-in bottom edges of the plates may be attached by fusion welding provided the load due to internal pressure is carried by staybolting and the inside width of the water leg does not exceed 4 in. as shown in Fig. P-7 1/2;[10] the plates may be considered as fully supported if the distance from the weld to the nearest row of staybolts is not more than one half the pitch allowed by the formula in Par. P-199.

Par. P-207. Omit.

Par. P-239(1). Revise to read as follows:

(*1*) The longitudinal joint may be OF THE riveted LAP TYPE UNLESS OTHERWISE SPECIFIED; or lapwelded by the forging process; OR FUSION-WELDED OF THE DOUBLE-WELDED BUTT TYPE THE ONLY REQUIREMENTS BEING THAT THE WELDS ARE STRESS RELIEVED IN ACCORDANCE WITH PAR. P-108 AND A BEND TEST OF A SAMPLE OF THE WELDING FOR EACH FURNACE MEETS THE REQUIREMENTS OF PAR. P-102, NO RADIOGRAPHIC EXAMINATION OR HAMMER TEST BEING REQUIRED; or the furnace may be of seamless construction.

Par. P-240(*1*) and (*4*). Delete.

Pars. P-242 and P-243. Add the following:

The longitudinal joint may be fusion-welded of the double-welded butt type the only requirements being that the welds are stress relieved in accordance with Par. P-108 and a bend test of a sample of the welding for each furnace meets the requirements of Par. P-102, no radiographic examination or hammer test being required.

Revise center heading preceding Par. P-258 to read:

ACCESS AND INSPECTION OPENINGS [MANHOLE, HANDHOLE AND WASHOUT OPENINGS].

Par. P-258. Revise to read:

P-258. [Manholes and Handholes.] ALL BOILERS OR PARTS THEREOF MUST BE PROVIDED WITH SUITABLE MANHOLE, HANDHOLE, OR OTHER INSPECTION OPENINGS FOR EXAMINATION OR CLEANING, EXCEPT SPECIAL TYPES OF BOILERS WHERE SUCH OPENINGS ARE MANIFESTLY NOT NEEDED OR USED.

FOR THE LOCATION AND SIZE OF SUCH OPENINGS FOR OTHER THAN WATER-TUBE BOILERS, SEE PARS. P-264, P-265, P-266 and P-267.

An elliptical manhole opening shall be not less than 11 × 15 in., or 10 × 16 in. size.

A circular manhole opening shall be not less than 15 in. in diameter.

A HANDHOLE OPENING SHALL BE NOT LESS THAN 2 3/4 × 3 1/2 IN., BUT IT IS RECOMMENDED THAT WHERE POSSIBLE, CONSISTENT WITH THE DIAMETER AND SIZE OF THE SHELL OR PLATE WHERE HANDHOLES ARE LOCATED, THEY BE 3 × 5 IN. OR 4 × 6 IN. SIZE.

[A] Handhole, inspection AND [or] washout openings in a shell or unstayed head shall be designed in accordance with the rules in Par. P-268.

WHEN A THREADED OPENING IS TO BE USED FOR INSPECTION OR WASHOUT PURPOSES, IT SHALL BE NOT LESS THAN 1 IN. PIPE SIZE. THE CLOSING PLUG OR CAP SHALL BE OF NONFERROUS MATERIAL (EXCEPT FOR PRESSURES OVER 250 LB).

THE THREAD SHALL BE A STANDARD TAPERED PIPE THREAD, EXCEPT A STRAIGHT THREAD OF EQUAL STRENGTH MAY BE USED IF OTHER SEALING SURFACES TO PREVENT LEAKAGE ARE PROVIDED.

Par. P-264. Omit first sentence.

Par. P-265. Revise the last sentence to read:

Where plugs are used, the requirements of Pars. P-258 AND P-268 shall apply.

Par. P-266. Revise to read:

P-266. *a* A vertical [fire-tube] boiler except WATER-TUBE TYPE AND boilers of steam fire engines AND [or] boilers less than 24 in. in diameter, shall have not less than FOUR [seven] handhole[s] OPENINGS IN THE SHELL located as follows: One [in the shell] at or about the water line or opposite the fusible plug when used; three [in the shell] at or about the line of the crown sheet OR LOWER TUBE SHEET, AND IF INTERNALLY FIRED NOT LESS THAN THREE ADDITIONAL HANDHOLE OPENINGS AT THE LOWER PART OF THE WATERLEG [three in the shell at the lower part of the waterleg].

A submerged-tube type of vertical fire-tube boiler 24 IN. OR MORE IN DIAMETER shall have two or more ADDITIONAL handhole[s] OPENINGS in the shell, in line with the UNDERSIDE OF THE upper tube sheet.

b A VERTICAL [ALL] boiler[s], EXCEPT OF THE WATER-TUBE TYPE, less than 24 in. in diameter, shall have [at least one] IN THE SHELL A HANDHOLE opening AT THE WATER LINE [for inspection] and two WASHOUT openings NEAR THE BOTTOM in addition to the blowoff for washing out the boiler, [these openings to be fitted with brass plugs. These openings shall be not less than 1 in. pipe size.] EXCEPT:

(1) IF OF THE INTERNALLY FIRED TYPE IT

[1] Fig. 8 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[2] Fig. 9 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[3] Fig. 10 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[4] Fig. 11 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[5] Fig. 12 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[6] Fig. 16 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[7] Fig. 17 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[8] Fig. 18 of A.W.S. Tentative Rules for Qualification of Welding Processes and Testing of Welding Operators.

[9] Same as figure appearing in Case No. 825.

[10] Same as figure appearing in Case No. 588.

SHALL HAVE A HANDHOLE OPENING IN THE SHELL IN LINE WITH THE CROWN SHEET OR LOWER TUBE SHEET, IN WHICH CASE THE HANDHOLE OPENING AT THE WATER LINE MAY BE OMITTED;

(2) IF OF THE SUBMERGED-TUBE TYPE IT SHALL ALSO HAVE A HANDHOLE OPENING IN THE SHELL IN LINE WITH THE UPPER TUBE SHEET IN WHICH CASE THE HANDHOLE OPENING AT THE WATER LINE MAY BE OMITTED.

c IF A VERTICAL-TYPE BOILER IS EQUIPPED WITH MANHOLES OR OTHER ACCESS OPENINGS THROUGH WHICH ADEQUATE INSPECTION MAY BE MADE, THE REQUIRED HANDHOLE AND/OR INSPECTION OPENINGS AT THE WATER LINE AND FOR THE TUBE SHEETS MAY BE OMITTED.

PAR. P-267. Revise to read:

P-267. A vertical fire-tube boiler of a steam fire engine shall have at least three [brass washout plugs] WASHOUT OPENINGS [of not less than 1 in. iron pipe size screwed into the shell and] located as follows: One at or about the line of the crown sheet; two at the lower part of the water leg.

PARS. P-268 and U-59. Insert the following as the first sentence.

The rules which follow and the charts in Fig. P-28 (U-4) apply only to shells in which there are tube holes or other plain unreinforced openings or which may be pierced with telltale holes without reducing the working pressure below that given by the rules in Par. P-180, and they are further limited to shells 8 in. or more in diameter in which the shell thickness does not exceed one fifth the diameter, and in which the largest hole does not exceed six tenths of the diameter of the shell.

Revise the second sentence of the second section of (*o*) to read:

WHERE A NOZZLE IS ATTACHED TO A BOILER (U-68 PRESSURE VESSEL) BY A FLANGE OR SADDLE INSERTED IN AND BUTT-WELDED TO THE SHELL AT THE EDGE OF THE FLANGE AS SHOWN IN FIG. P-29$^1/_2$,[11] THE WELD SO MADE SHALL BE RADIOGRAPHED. RADIOGRAPHIC [X-ray] examination OF OTHER TYPES OF NOZZLES may be omitted.

PAR. P-270. Add the following sentence:

The maximum steaming capacity of a boiler shall be determined by the manufacturer and shall be based on the capacity of the fuel-burning equipment, on the air supply, draft, etc.

PAR. P-274. Revise first paragraph to read:

The minimum STEAMING [aggregate relieving] capacity FOR WHICH [of all of] the safety valve [or valves] RELIEVING CAPACITY IS required [on a boiler], shall be [that] determined on the basis of THE [six] pounds of steam GENERATED per hour per square foot of boiler heating surface AND WATERWALL HEATING SURFACE, AS GIVEN IN THE FOLLOWING TABLE [for water-tube boilers:]

	Boiler heating surface			Waterwall surface		
	Hand fired	Stoker fired	Oil, gas, or pulverized-fuel-fired	Hand fired	Stoker fired	Oil, gas, or pulverized-fuel-fired
Fire-tube boilers............	5	7	8	8	10	14
Water-tube boilers...........	6	8	10	8	12	16

IN MANY CASES A GREATER RELIEVING CAPACITY OF SAFETY VALVES WILL HAVE TO BE PROVIDED THAN THE MINIMUM SPECIFIED BY THIS RULE, AND IN EVERY CASE THE REQUIREMENTS OF PAR. P-270 SHALL BE MET.

PAR. P-325*c*. Revise first sentence to read:

c Lugs, hangers or brackets [of the same size as required for riveting and] made of materials in accordance with the Code requirements.....represents the shell thickness.

Add the following sentences:

Fig. P-32$^1/_2$[12] shows an acceptable design of hanger bracket for fusion-welded attachment to welded hrt boilers with the additional requirement that the hanger pin be located at the vertical center line over the center of a welded contact surface. The bracket plates shall be spaced at least 2$^1/_2$ in. apart, but this dimension shall be increased if necessary to permit access for the welding operation.

PAR. P-331. Revise to read:

P-331. *Identification of Plates. a* When the boiler is completed, there shall remain visible on shell plates, furnace sheets and heads, one group of the plate manufacturer's stamps, consisting of the manufacturer's name, manufacturer's test identification number, class and tensile strength; except that heads containing tube holes and butt straps shall have visible at least a sufficient portion of such stamps for identification.

b It is permissible to transfer, without imitation, the markings on the plate under authority of the inspector in charge; said inspector to put his private mark after the transferred stamp, making a record of such stamp transfer on the data sheet.

c An authorized representative of the plate manufacturer may duplicate the required stamping on any material wherever located.

PAR. P-332. Revise to read:

P-332. *Manufacturer's Stamping. a* Each boiler, superheater, waterwall and steel economizer shall conform in every detail to these rules and shall be distinctly stamped with the symbol as shown in Fig. P-33, denoting that the construction is in accordance therewith.

b Each boiler, superheater, waterwall, or steel economizer, and parts thereof, constructed to conform with this section of the Code shall be inspected during construction and after completion by a state inspector, or a municipal inspector of any state or municipality that has adopted the Code, or an inspector employed regularly by an insurance company, and who is qualified by a written examination under the rules of such states or municipalities. At least two inspections shall be made of riveted shells, one before reaming rivet holes and one at the hydrostatic test. For inspection of welded construction see Par. P-110. If the construction is in compliance with the Code the builder shall stamp it in the presence of the inspector, after the hydrostatic test, with the A.S.M.E. Code symbol stamp, the builder's name and the serial number of the manufacturer.

c Data reports shall be filled out and signed by the manufacturer and the inspector, which reports, together with the stamping applied, shall be a guarantee by the manufacturer that he has complied with all the requirements in this section of the A.S.M.E. Boiler Code (a sample data report appears opposite page 122).

d When parts requiring Code inspection are furnished by other than the shop of the manufacturer responsible for the completed boiler, superheater, waterwall, or steel economizer, such parts shall be fabricated by a manufacturer in possession of a Code symbol stamp. Data reports in triplicate covering such part or parts shall be executed by the manufacturer thereof and the inspector and forwarded in duplicate to the manufacturer of the finished boiler, superheater, waterwall, or steel economizer. This partial data report, together with his own inspection, shall be the inspector's authority to witness the application of the Code stamp. The manufacturer who completes the unit and the authorized inspector making final inspection shall be responsible for its meeting Code requirements (a sample manufacturer's partial data report form appears on page 122).

e In cases where boilers, superheaters waterwalls and steel economizers cannot be completed and hydrostatically tested before shipment, proper stamping shall be applied at the shop and two data sheets signed by the same or different inspectors covering the portions of the inspections made at the shop and in the field, the data sheets each to be separately sent to the proper destination.

f Each boiler shall be stamped adjacent to the symbol as shown in Fig. P-34, with the following items with letters and figures at least $^5/_{16}$ in. high, having intervals of about $^1/_2$ in. between the lines:

(1) A.S.M.E. serial number, which may be the manufacturer's serial number
(2) Name of manufacturer
(3) Maximum allowable working pressure when built
(4) Heating surface of boiler, in sq ft
(5) Heating surface of waterwall, in sq ft
(6) Year built.

g To remain the same as in the present Code.

h To remain the same as in the present Code.

PAR. P-333. Add the following:

(11) On superheaters—on superheater header near the outlet
(12) On economizers—at a handy location on water inlet header or drums
(13) On waterwalls—on one end of a lower header.

PAR. A-19*d*. Add the following to proposed revision appearing in June, 1936, issue of MECHANICAL ENGINEERING:

The fusible metal may be partly replaced by a bronze plug loosely fitted to the hole

[11] Same as figure appearing in Case No. 835.

[12] Same as figure appearing in Case No. 831.

and of such size that it will pass freely through the hole on the fire side, from which side it must be inserted into the casing. Such plug shall be properly alloyed to the casing with the same fusible metal as required by (*a*).

PAR. A-20*d* and *e*. Modify proposed revisions of (*d*) and (*e*) appearing in June, 1936, issue of MECHANICAL ENGINEERING to read and omit (*g*):

d The bore of the casing shall be tapered continuously from the water end of the CASING [plug] for a distance of at least 1 in. to a diameter of not less than $^3/_8$ in. AT A POINT NOT LESS THAN $^1/_2$ IN. FROM THE FIRE END. The diameter of the bore [on the water] AT EITHER end shall not be less than $^1/_2$ in. The hole on the fire END [side of the plug] shall be as large as possible and may be of any [size or] shape provided the cross-sectional area at all points is greater than the area of the least cross section of the fusible metal. [Except that the hole on the water end may be made not less than $^3/_8$ in. diameter with parallel sides, if it is filled with a loose-fitted bronze plug which is properly alloyed to the casing with the same fusible metal otherwise required for a fusible core in Par. A-19*a*. The hole on the fire side must be large enough for the free passage of the bronze plug and it must be inserted into the casing from this side.]

e A fusible plug shall be of such length that when installed it shall project at least $^3/_4$ in. on the water side of the plate, tube, or flue. It shall extend through the plate, tube, or flue on the fire side as little as possible but not more than 1 in.

Specifications S-8. To be revised to be identical with A.S.T.M. Specifications A 105–36.

Specifications S-12. To be revised to be identical with A.S.T.M. Specifications A 95–36.

Specifications S-14 to be omitted.

Specifications S-36. This new specification will be identical with A.S.T.M. Specification B 96–36T on Specifications for Copper-Silicon Alloy Plates and Sheets.

Specifications S-37. This new specification will be identical with A.S.T.M. Specification B 98–36T on Specifications for Copper-Silicon Alloy Rods, Bars, and Shapes.

Specifications S-38. This new specification will be identical with A.S.T.M. Specification B 25–34T on Aluminum Sheet and Plate.

Specifications S-39. This new specification will be identical with A.S.T.M. Specification B 79–34T on Aluminum-Manganese Alloy Sheet and Plate.

Specifications S-40. This new specification will be identical with A.S.T.M. Specification B 192–36T for Seamless Steel Boiler Tubes for High-Pressure Service.

Specifications S-41. This new specification will be identical with A.S.T.M. Specification B 61–36T for Steam or Valve Bronze Castings.

PAR. H-21. Add the following as *b:*

b Boilers for a maximum allowable working pressure of 15 lb steam and 30 lb water may be constructed with a horizontal furnace of semicircular design with the upper part of the semicircular portion not exceeding 120 deg, unsupported by staybolts, or other means of support recognized in this Code. The minimum required thickness shall be that given by the chart in Fig. 00 (this chart to give shell thicknesses which are $1^1/_2$ times those shown by the diagram in Fig. U-21 for a maximum allowable pressure of 30 lb per sq in.).

Where

L = total length of furnace between rivet centers, in., not to exceed 72 in.

D = diameter of furnace, in., not to exceed 60 in.

t = minimum required thickness of shell plate, in.

PAR. M-1. Revise the definition of length to read:

42 in. length of shell (CYLINDRICAL PORTION UNDER PRESSURE).

Add the following:

For boilers of the flash type or those having a forced circulation with no fixed steam or water line, the materials used shall comply with the Code. All other Code requirements shall be met except where they relate to special features of construction made necessary in boilers of this type and to accessories that are manifestly not needed or used in connection with such boilers, such as water gages, water columns, and gage cocks.

PAR. M-3*a*. Revise as follows:

a Steel plates subject to pressure in any part of a miniature boiler of riveted construction shall be of the firebox or flange grades. THE PLATES for [riveted] shells OR HEADS [the plates] shall not be less than $^1/_4$ in. in thickness EXCEPT THAT [and for] seamless shells shall not be less than $^3/_{16}$ in. in thickness. REMOVABLE HEADS AND THE FLANGES TO WHICH THEY ARE ATTACHED SHALL BE DESIGNED IN ACCORDANCE WITH THE RULES IN PARS. UA-16 TO UA-22, INCLUSIVE. Heads used as tube sheets with tubes rolled in, shall be at least $^3/_{16}$ in. in thickness.

PAR. M-20. Revise fifth section to read:

The markings required on a boiler shall be stamped with letters and figures at least $^3/_{16}$ in. in height on some conspicuous portion of the boiler proper EXCEPT THAT, FOR BOILERS HAVING NO PRESSURE PARTS OTHER THAN THE STEAM GENERATING COIL OR TUBING, THE REQUIRED STAMPINGS MAY BE PLACED ON A SEPARATE, NONFERROUS PLATE NOT LESS THAN 3 by 4 IN. SIZE WHICH SHALL BE AS IRREMOVABLY AS POSSIBLE ATTACHED TO THE FRONT OF THE BOILER CASING.

PAR. U-1*a*. Add the following as a footnote to "*V*:"

When the interior chamber of a jacketed vessel is open and not subject to pressure, the factor "*V*" applies only to the jacket. When both the interior chamber and the jacket are subject to pressure, the factor "*V*" applies to the entire volume of the vessel.

Annual proposed revision of definition of "*P*" given in March, 1937, issue of MECHANICAL ENGINEERING.

PAR. U-3. Revise to read:

U-3. Safety valves shall be of the direct spring-loaded type and shall be A.S.M.E. standard valves bearing the A.S.M.E. symbol.

PAR. U-4. Delete.

PAR. U-13. Revise (*e*) to read:

e Tubes conforming with Specifications S-17 for Lapwelded and Seamless Steel and Lapwelded Iron Boiler Tubes, OR S-32 FOR ELECTRIC-RESISTANCE WELDED STEEL AND OPEN-HEARTH IRON BOILER TUBES may be used in unfired pressure vessels.

Add the following:

g Nonferrous plates may be used in the construction of unfired pressure vessels when specifications are given in Section II and stresses as provided in Par. U-20 are followed.

h Cast iron which meets the requirements of Specification S-13 may be used in the construction, wholly or in part, of unfired pressure vessels provided the pressure does not exceed 160 lb per sq in., or the temperature does not exceed 450 F for steam or other gases, or 250 F for liquids except that vessels of cast iron or cast-iron pressure parts shall not be used as containers of lethal liquids or gases.

A working stress of not to exceed 2500 lb per sq in. shall be used in designing cast-iron pressure parts of such shape that the rules of this code for calculating pressure are applicable.

Ample fillets at all corners shall be provided and abrupt changes in shape and thickness shall be avoided.

Cast-iron pressure parts conforming to the requirements of the several A.S.A. standards for cast-iron fittings may be used as a whole or part of pressure vessels for temperatures not exceeding 450 F and for pressures not exceeding the A.S.A. ratings.

TABLE U-$3^3/_4$ MAXIMUM ALLOWABLE WORKING STRESSES IN POUNDS PER SQ IN.

Material	Spec. no.	For temperatures not exceeding deg F: Sub-zero	150	250	350	406	450	500	550
Copper plates	S-20	6000	6000	5000	4500	4000	..	..	..
Copper-silicon-alloy plates, rods, bars and shapes	Note 1	10,000	10,000	10,000	..	..	..	..	..
Monel	Note 2	12,000	12,000	12,000	11,000	10,000	9000	8000	7000
Aluminum	Note 3	2600	2300	1800	1300	1050	800	600	..
Aluminum alloy	Note 4	3200	3000	2500	2000	1750	1500	1300	..

Note 1: Code Specification S-36 (ASTM Specifications B96–36T).
Code Specification S-37 (ASTM Specifications B98–36T) Types A and C only.
Note 2: Applies to 60,000 lb per sq in. tensile strength annealed material.
Note 3: Code Specification S-38 (ASTM Specifications B25–34T).
Note 4: Code Specification S-39 (ASTM Specifications B79–34T).

Cast-iron vessels or cast-iron parts shall be hydrostatically tested to $2^1/_2$ times the maximum allowable working pressure but in no case less than 60 lb.

PAR. U-20. Add the following as *d*:

d Nonferrous Plates. Maximum allowable working stresses for nonferrous materials conforming to specifications in Section II of the Code shall not exceed the values given in Table U-$3^3/_4$ for metal temperatures shown. For welded joints, where permitted, a joint efficiency of 80 per cent must be used.

PAR. U-36*c*. Insert the following as the first sentence:

A head may be made from a single sheet, or built up of several pieces joined together.

To change the formula to read:

$$t = \frac{8.33 \times P \times L}{2 \times TS \times E}$$

Add the following definition:

E = efficiency of weakest joint used in forming the head;
for seamless heads E = 100 per cent.

PAR. U-53. Revise to read:

U-53. *a* All unfired pressure vessels for use with compressed air or subject to internal corrosion shall be provided with suitable manhole, handhole, or other inspection openings for examination and cleaning, except that such openings may be omitted from vessels containing compressed air when the actual service conditions or other material stored in them are such that the vessel is not subject to internal corrosion.

b An elliptical manhole shall not be less than 11 × 15 in., or 10 × 16 in. size. A circular manhole shall not be less than 15 in. in diameter.

c A handhole opening shall not be less than 2 × 3 in. size but it is recommended that they be as large as possible consistent with the size of the vessel and the location of the opening.

d All access and inspection openings in a shell or unstayed head shall be designed in accordance with the rules in Par. U-59.

e When a threaded inspection opening is to be used for inspection or cleaning purposes, it shall not be less than $1^1/_2$ in. pipe size. The closing plug or cap shall be of a material suitable for the pressure and temperature conditions. Bronze shall not be used for temperatures over 450 F.

The thread shall be a standard tapered pipe thread except that a straight thread of equal strength may be used if other sealing surfaces to prevent leakage are provided.

PAR. U-54. Revise to read:

U-54. All vessels which require access or inspection openings shall be equipped as follows:

a All vessels less than 18 in. in diameter shall have at least two handholes or two plugged threaded inspection openings.

b All vessels 18 to 36 in., inclusive, in diameter shall have at least two handholes or two plugged threaded inspection openings of not less than 2 in. pipe size, or a manhole.

c All vessels over 36 in. in diameter shall have a manhole except those whose shape or use make it impracticable, in which case they shall have at least two 4 × 6-in. handholes, or two handholes of equivalent area.

d When handholes or plugged openings are used for inspection openings in place of a manhole, where permitted, one handhole or one plugged opening shall be placed in each head or in the shell near each head.

e Removable heads or cover plates may be used in place of the required openings provided they are equal at least to the required size of the required inspection openings.

A single removable head or cover plate may be used in place of all other inspection openings if it is of such size and location that a general view of the interior may be obtained through the opening at least equal to that obtained through the inspection openings otherwise required.

f In special cases where vessels 16 in. or less in diameter are located so that inspections cannot be made without dismantling or removing the vessel, special openings need not be provided if the tapping for pipe connections properly located for inspection purposes is not less than $1^1/_2$ in. pipe size.

PAR. U-66*a*. Add the following:

When an unfired pressure-vessel unit consists of more than one pressure chamber, operating at the same or different pressure, each such pressure chamber (vessel) shall be subject to the required inspections and hydrostatic tests.

The required hydrostatic tests shall be applied to each separate pressure chamber without pressure in the others. After passing the inspections and hydrostatic tests, each pressure chamber shall be stamped and a data sheet made out for each as required for a single vessel by Pars. U-65 and U-66.

FIG. U-13. Revise length of test plate to read "not less than 10 in."

LETTERS *and* COMMENT

Direct Computation of Pipe-Line Discharge

TO THE EDITOR:

Instead of the formerly necessary trial-and-error and graphical-interpolation methods, the discharge from a pipe line can be directly computed from its friction loss by using the theoretical velocity V_t, in place of the actual average velocity V_a, in the Reynolds number and by considering a 100-diameter length ($L = 100D$) of pipe as a flow meter.

$$V_t \text{ (fps)} = 8.02 \sqrt{h_f} \qquad [1]$$

A conventional relation between friction loss and velocity is

$$h_f \text{ ft} = f(L/D)\, V_a^2/2g \qquad [2]$$

and between velocity and friction loss is

$$V_a \text{ (fps)} = C\, 8.02 \sqrt{h_f} \qquad [3]$$

where

$$C = 1/\sqrt{100 f} \qquad [4]$$

To calculate the discharge velocity V_a from the friction loss h_f in 100 diameters of smooth brass pipe, one calculates the theoretical velocity V_t from equation [1], then the alternative form of the Reynolds number, V_tD/ν, and, from Fig. 1, obtains the corresponding value of the friction factor f, and *directly* computes the actual discharge velocity V_a from equations [3] and [4].

Other work[1] by the writer on this general subject is contained in the article "Alternative Forms of the Reynolds Number." The present material is only one of many useful implications, others obviously being in flow metering. That an alternative form of the Reynolds number for gas could be plotted advantageously on a top scale for use in connection with the Weymouth formula is readily apparent. This material can be readily put into nomographic and slide-rule form by its users.

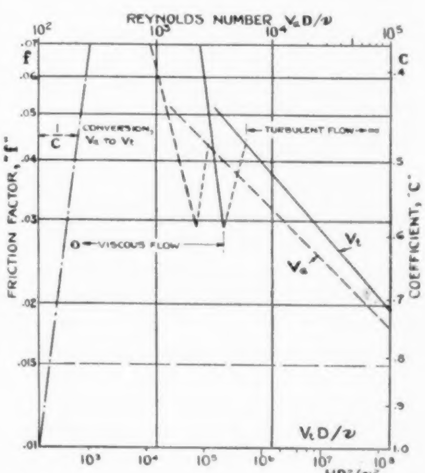


FIG. 1 DIRECT COMPUTATION OF DISCHARGE FROM PIPE FRICTION

ED S. SMITH, JR.[2]

[1] "Alternative Forms of the Reynolds Number," by Ed S. Smith, Jr., *Instruments*, vol. 8, 1935, p. 201.

[2] C. J. Tagliabue Mfg. Company, Brooklyn, N. Y. Mem. A.S.M.E.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Mechanics of Turbulent Flow

The Mechanics of Turbulent Flow. By Boris A. Bakhmeteff. Princeton University Press, 1936. Cloth, 6 × 9 in., 101 pp., 62 figs., $3.50.

Reviewed by J. C. Hunsaker[1]

PROFESSOR Bakhmeteff of Columbia has, in these four lectures delivered at Princeton in 1935, supplied the key to an understanding of the modern enthusiasm for turbulence research and theory. The last century saw a considerable body of empirical facts built up under the name of hydraulics and an imposing body of applied mathematics under the name of hydromechanics. There was little practical relation between the two, because hydromechanics dealt with an ideal frictionless fluid giving rise to no resistance. However, Newton laid the foundations of our knowledge of viscous resistance and Osborne Reynolds clarified the conception of turbulence and fluid friction. With the aid of the principle of dynamical similitude, Rayleigh and later Stanton established the supreme importance of Osborne Reynolds' work.

In our own time, Prandtl in Göttingen and his pupil von Kármán, G. I. Taylor in England, and others have accomplished the long-sought goal of a theory which predicts many of the results of experiment. The steps by which this great achievement has been accomplished have been described by their several authors in scattered publications over the past twenty years. These publications are not generally available or really intelligible except to the specialist. Yet, engineers now are required to make applications of the modern theory to practical flow problems.

Professor Bakhmeteff has reconstructed the whole story so that the modern theory appears to result naturally and inevitably from elementary mechanical principles. He has done this with elegance and precision for the simple case of pipe-line flow, and in so doing has avoided the complications of flow separation, potential fields, and heat transfer where the theory is not yet perfected.

His procedure is to discuss in the first lecture the fundamental concepts of energy loss and shear for viscous flow, turbulence, and Osborne Reynolds' work, dynamical similitude, laminar and turbulent friction, resistance, and roughness.

The second lecture develops the mechanics of turbulent flow and Prandtl's fruitful conception of the mixing length. The Prandtl boundary layer and the laminar sublayer are clearly described, together with the velocity distribution appropriate to the flow conditions in the pipe. The important theoretical distinction between rough and smooth pipes is explained and experimental evidence is quoted to relate the mixing length to the velocity distribution.

In the third lecture, von Kármán's concept of a geometrical pattern of turbulent flow is used to develop an expression for the mixing length in terms of only one experimental constant, which is identical throughout the whole region of turbulent motion. The equation of motion can then be integrated, yielding the velocity distribution across the pipe and the friction coefficient.

Professor Bakhmeteff next tests the theory against the experiments of Nikuradse and suggests that near the center of the pipe where the velocity gradient vanishes, the mixing length predicted by theory is too large. But here large errors have small effect. He says: "One may safely proceed in developing the final practical formulae for smooth and rough pipes, leaving further coordinating and perfecting to future research."

The last lecture gives the meat of the whole matter in the form of formulas for the use of engineers in dealing with pipe-line flow problems. Theoretical and experimental data are harmonized on nondimensional plots, giving velocity contours, resistance coefficients, and film thickness for smooth and rough pipes. The rough pipes, however, in the present state of our knowledge are of an artificial sort in which the roughness is made geometrically similar for the series.

Future research will, no doubt, concern itself with a clarification of the effect of roughness on the flow pattern so that some day one experiment may be used to determine all the necessary numerical factors for the computation of the flow of any fluid through any pipe of the specified roughness.

Professor Bakhmeteff pays a high tribute to the work of Prandtl and von Kármán and concludes: "The Prandtl-Kármán structure stands at present not only as a most notable memorial to the ingenuity of modern research but also as a practical contribution of first magnitude."

[1] Professor in charge of Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. Mem. A.S.M.E.

Evaluation and Payment of Labor

Compensating Industrial Effort. By Z. Clark Dickinson. Ronald Press, New York, N. Y., 1937. Cloth, $5^3/_4 \times 8^3/_4$ in., 479 pp., $4.50.

Salaries, Wages, and Labor Relations. By J. O. Hopwood. Ronald Press, New York, N. Y., 1937. Cloth, $5^3/_4 \times 8^3/_8$, 124 pp., 19 figs., $2.50.

Reviewed by Chas. W. Lytle[2]

THESE two books center around the same general problem, that is, the evaluation and payment of labor. Aside from this identity of problem, however, the books are as different as they can be. The first book is long, 479 pp., cites cases from all over the world, and is the result of considerable scholarship, that is, book research. The second book is short, 124 pp., is essentially one case and is the result of 15 years' practical development in a single public utility. Let us examine them separately, beginning with the one named first.

Professor Dickinson is an economist who has interests in the psychological and sociological fields. In many places, his treatment is disappointing to an engineer, but he modestly disclaims any attempt to cover technical aspects, and he does give very much that the engi-

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neers have too often ignored. A few quotations will perhaps disclose even better than the title just what is attempted.

> We attempt to impart into the subject of wage methods something of the experimental and statistical point of view which characterizes the natural science types of research on working conditions.

Certainly the author is not a proponent of wage incentives for all industrial work.

> Payment by results is feasible only when a relatively standard product, practicably inspected and counted, is turned out on a large scale in the aggregate, and under conditions sufficiently uniform so that a certain skill and effort in the worker will produce approximately similar output wherever applied.

Again

> There is a good deal to be said for the communistic argument that we should ideally abandon the attempt to distribute incomes according to "productivity" and should dispense them equally to all persons or at least according to some other scheme than the recipients' supposed output.

Thus, in the early part of the book, he stresses the laudable purpose of collecting and disentangling actual results but in some chapters does not accomplish it.

Chapters 2 and 3 are largely on experimental psychology. The author himself suggests that these may be skipped! He still seems to be groping in chapter 4. In fact, overexalts the term labor cost. For instance: "consumers...are thus interested in low labor costs" and "employer should be most interested in his labor cost." We think the term total cost per unit would be more exact.

In chapter 5, he discusses the recent shift from gang piece rate to day rate in the automotive industry without making it clear that a mechanically controlled production rate involves a condition which can have neither true piece rate nor true time rate regardless of what it may be called. Chapter 6 is a four-page outline of subsequent chapters. Chapter 7 is devoted largely to the Probst's merit-rating system. Chapter 8 takes up the problem of deriving a standard task. Here, he again is out of his field. The one sample time study is bad if not obsolete practice and little of the chapter is practical or up to date.

More happily, chapters 9, 10, and 11 covering base rates, wage theories, appraisal of NRA, and job analysis are within his natural field and are all excellent. Chapter 12 covering wage differentials is particularly worth studying.

As chapters 13 and 14, on incentive plans and individual and group applications, fall in the engineering field, the author is again faulty. A single composite chart is given for the earning curves of five plans. The Halsey and Rowen plans are made to start at 100 per cent efficiency, where the author assumes time-payment efficiency. The Taylor and Wennerlund plans have a relative task efficiency of 150 per cent. The below-task portion of the Taylor plan is distorted to coincide with basic piece rate and the above-task portion of the Emerson plan is omitted altogether! The latter is described correctly, and that is pretty good for a nonengineer. The unfortunate choice of the efficiency scale carries it to 300 per cent, which would have been a bad shock to Mr. Taylor if not to Mr. Emerson. The lack of any symbols may be offset by the fact that this writer did not invent new ones as so many writers have thought necessary to do.

Chapter 15 gives the results of the valuable experiments carried on by the Western Electric Company and the British Health Board. These are well done and most constructive. Chapters 16 and 17 covering profit sharing, executive bonus, copartnerships, and coptation are decidedly comprehensive, considering the space. Here and again in chapters 18 and 19 on suggestion systems, the historical background alone makes them particularly worth while. The whole international experience is unfolded in a clear treatment. We hope, however, that the readers will be prepared for such words as "recidivism." The last, and to the reviewer the best, chapter, 20, is on interest, monotony, nonpecuniary incentives and similar topics. On such subjects, the author writes convincingly, and we feel that these data and conclusions are worth the price of the book.

Mr. Hopwood's book is difficult to review because the author touches little except his own company development. It certainly is practical and concise. The chapter headings may give some conception of scope and are as follows: 1, Introduction; 2, Payroll Administration and Labor Relations; 3, Organization Relations and Job Analysis; 4, Job Evaluation; 5, Coordination of Compensation Standards; 6, Job Classification; and 7, Administrative Procedures and Records.

The author at the start shows his philosophy by declaring that the "going-rate" is obsolete. The following extracts are typical:

> People work, not in industry at large, nor as classes of workers, but as individuals employed in enterprises...We must know our own business...what are the jobs of all the people in it, how should they be evaluated, and how should standards of compensation be established with respect to these evaluations, individual competences, and the income available for distribution via the payroll?... Few persons can duplicate their salaries elsewhere when they find themselves out of jobs.

Except for such expressions, the book is an internal inquiry and a one-company answer. Fortunately, the company is a progressive one, and its solution should be of value to many others. We wonder, however, if such things as organization charts, job specifications, and the like will mean much in any other situation. Perhaps the method of setting up illustrated by them is sufficiently general to be applicable, even if the fit of the whole is not perfect. In fact, the discussions are more general than one might expect from the case nature of the book. At least, the case is an excellent one, well-written and complete as far as it goes.

Books Received in Library

Absorption and Extraction. By T. K. Sherwood. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 278 pp., illus., diagrams, charts, tables, $3.50. This volume outlines the underlying theory of such important diffusional processes as absorption, extraction, drying, humidification and dehumidification, and discusses the engineering problems connected with the design and operation of equipment for absorption and extraction. It includes a summary of the available performance data upon various types of equipment and has a chapter on the basic principles of solvent extraction. There is a bibliography.

Atm—Archiv für Technisches Messen. Lieferungen 67 and 68, Jan.–Feb. 1937. R. Oldenbourg, Munich and Berlin. Paper, 8 × 12 in., illus., diagrams, charts, tables, 1.50 rm. each. Two numbers of an irregular series of articles on measurement technique and measuring instruments, intended as a loose-leaf encyclopedia of technical measurement. The material is classified and punched for filing. No. 68 includes an index to the entire series.

Applied Chemistry for Engineers. By A. F. H. Ward. Longmans, Green and Co., New York and London, 1936. Cloth, 5 × 8 in., 127 pp., diagrams, charts, tables, $1.75. A collection of experiments dealing with water analysis, boiler feedwater, corrosion, coal and oil, intended as a text for students of engineering. Sufficient theory is given to elucidate the experimental procedures.

Art and the Machine, an Account of Industrial Design in 20th-Century America. By S. Cheney and M. C. Cheney. McGraw-Hill Book Co. New York (Whittlesey House), 1936. Cloth, 7 × 10 in., 307 pp., illus., $3.75. The new field of "industrial

design" is the thesis of this book. It is maintained that the alliance of artist with mechanic, preferably in the same person, to produce functional forms having aesthetic values is the beginning of a new style, possibly a new culture. The development of this blending experiment is traced through the last few decades. Numerous photographs, mainly of actual products, illustrate the text.

BERICHTE DES DEUTSCHEN AUSSCHUSSES FÜR STAHLBAU, Ausgabe B, Heft 7. ÜBER DAS VERHALTEN GESCHWEISSTER TRÄGER BEI DAUERBEANSPRUCHUNG UNTER BESONDERER BERÜCKSICHTIGUNG DER SCHWEISSSPANNUNGEN, by G. Bierett. Julius Springer, Berlin, 1937. Paper, 21 pp., illus., diagrams, charts, tables, 3.60 rm. In making welded beams, large welding stresses occur. It has been shown that these have no great effect upon the carrying capacity under static loads, but less is known concerning the effect of dynamic loads. The present report describes experiments to clarify this question.

BLUE BOOK OF FACTS OF MARINE ENGINEERING. Eleventh edition, 1937. Ocean Publishing Co., New York. Cloth, 4 × 6 in., 172 pp., diagrams, charts, tables, $3. A catechism for the use of those preparing for examinations for licenses as marine engineers.

COAL, Its Constitution and Uses. By W. A. Bone and G. W. Himus, with supplementary chapter by R. J. Sarjant. Longmans, Green & Co., London and New York, 1936. Cloth, 6 × 10 in., 631 pp., illus., charts, tables, $7.50. The economic, geological, chemical, and technological aspects of coal are comprehensively treated in this work, which follows the general lines of the author's "Coal and its Scientific Uses," but deals more particularly with the present "problems of coal in the light of recent developments and research from a world-wide standpoint as well as that of national interest." The results of recent researches on the chemical constitution and geological history of the lignin-peat-coal series are given, and a number of chapters are devoted to the preparation of coal for the market, the uses of pulverized fuel, boiler design and management, smoke abatement, the carbonization industries, hydrogenation, domestic heating, surface combustion, fuel economy in iron and steel manufacture, and heat transmission in industrial furnaces. Each chapter has a bibliography. The work is an important addition to the literature of fuel technology.

DAVISON'S RAYON AND SILK TRADES STANDARD GUIDE. 42nd pocket edition, 1937. Davison Publishing Co., New York. Leather, 5 × 8 in., 588 pp., illus., maps, $5.50. This annual guide to the silk and rayon trades contains yearly revised lists of important facts in the field, as follows: Classified buyers' guide of equipment and materials; geographical, classified and alphabetical lists of manufacturers of fabric products; designers, dyers, dealers; and a key indicating the railroads serving each manufacturer.

DEUTSCHES MUSEUM. Abhandlungen und Berichte, Jg. 8, Heft 5, 1936. ENTWICKLUNG DER KINOTECHNIK, by R. Thun. V.D.I. Verlag, Berlin. Paper, 6 × 8 in., pp. 111–138, illus., 0.90 rm. This pamphlet gives a brief popular outline of the development of moving pictures, from the beginning to the present.

DURALUMIN AND ITS HEAT-TREATMENT. By P. L. Teed. Charles Griffin & Co., Ltd., London, 1937. Cloth, 6 × 9 in., 116 pp., illus., diagrams, charts, tables, $6. A book for engineers interested in duralumin rather than for metallurgists. The introduction gives briefly the characteristics and development of the alloy. A chapter on age hardening precedes the heat-treatment chapters, which cover annealing and "normalising" (final heat-treatment), with some miscellaneous information as to heating baths and equipment layout. A great deal of the material is the result of a long series of experiments.

ECONOMICS OF THE IRON AND STEEL INDUSTRY. Two volumes. (Bureau of Business Research Monographs, No. 6.) By C. R. Daugherty, M. G. de Chazeau, and S. S. Stratton. McGraw-Hill Book Co., New York and London, 1937. Cloth, 6 × 9 in., 1188 pp., diagrams, charts, maps, tables, $12. "The purpose of this study has been to set forth in considerable detail the economic conditions surrounding the production and distribution of iron and steel in the United States and, in that setting, to present and analyze the major problems of the industry as they manifested themselves in the industry's operations under the Code of Fair Competition for the Iron and Steel Industry, with a view to determining whether that Code or any similar regulatory instrument was or could be made socially advantageous..... The analysis and the conclusions reached are applicable only to the iron and steel industry."...To this quotation it seems well to add the fact, that, in view of the short and disorganized period during which the Code was in force, information has been assembled and analyzed covering the period 1924–1934.

ELEMENTS OF RAILROAD ENGINEERING. By W. G. Raymond, revised by H. E. Riggs and W. C. Sadler. Fifth edition. John Wiley & Sons Inc., New York, 1937. Cloth, 6 × 9 in., 406 pp., illus., diagrams, charts, tables, $4.25. The main revision in this new edition of a fundamental work on railroad engineering has come in the earlier sections. The introductory chapter on history and development has been expanded to several, as a consequence of the changes in late years. The section on permanent way, covering rails, roadbed, bridges, yards and signaling, and the section on locomotives and other equipment have been necessarily revised in the light of modern practice. The last section on location, construction, and surveys has been left essentially as it was.

EVERY DAY BUT SUNDAY, the Romantic Age of New England Industry. By J. F. Copeland. Stephen Daye Press, Brattleboro, Vt., 1936. Cloth, 6 × 9 in., 294 pp., illus., $2.50. This is the story of Mansfield, Massachusetts, carried to the end of the ninetenth century. Particularly is it the story of its industries and the changes that they underwent. The manufacture of tacks and nails, of cotton and straw bonnets, the mining of coal, basket and cutlery making, founding and jewelry manufacture have at various periods occupied the community. These are described and in addition the entertainments and amusements of the town are set forth. The book gives a vivid picture of an early industrial community, of considerable historic interest.

FORSCHUNGSHEFT 382. January–February, 1937. V.D.I. Verlag, Berlin, 1937. Paper, 8 × 12 in., 31 pp., illus., diagrams, charts, tables, 5 rm. This number contains two researches. The first is a study of heat transfer and molecular transfer of matter in the same field at large differences of temperature and partial pressure, at which the combined effect of these two phenomena must be taken into account. The second deals with the condensation of steam in the form of drops, presenting the results of a study of the conditions under which this occurs.

GASMASCHINEN UND KOMPRESSOREN MIT WASSERKOLBEN. By C. Stauber; mit einem Anhang: Die Flüssigkeitsbewegung in Wasserkolbenmaschinen, by F. Engel. R. Oldenbourg, Munich and Berlin, 1937. Paper, 7 × 10 in., [illegible] pp., illus., diagrams, charts, tables, 9.80 rm [illegible] In this interesting book, the author present[illegible]e results of his extended study of the pos[illegible]lity of using water instead of metal pistons in gas engines and compressors. A review of the work done in this field is given, and the results discussed critically. An appendix by Dr. Engel discusses fluid motion in water-piston engines.

GRAPHOSTATIK. (Teubners Mathematische Leitfäden, Bd. 42.) By E. Trefftz. B. G. Teubner, Leipzig and Berlin, 1936. Paper, 6 × 8 in., 90 pp., diagrams, charts, 6.40 rm. (4.80 rm. in U. S. A.) A concise, up-to-date textbook of graphic statics, intended especially for students of engineering. The book is based upon courses given to students of mechanical and electrical engineering at the Dresden Technical High School.

GREAT BRITAIN. DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH. Report for Year 1935–1936. His Majesty's Stationery Office, London, 1937. Paper, 6 × 10 in., 195 pp., tables (obtainable from British Library of Information, New York, $0.95). This report affords a comprehensive summary of the work carried on during the year in the various establishments of the Department. Each report includes a list of articles published as a result of the investigations. A summary of the work of other British research institutions is also presented, so that the book forms a convenient review of all scientific and industrial research in Great Britain. Useful appendixes give the membership of the Department committees, the addresses of its establishments, the addresses and directors of other research institutions, of publications by the recipients of grants for research, and of the departmental publications.

(The) HANDMAIDEN OF THE SCIENCES. By E. T. Bell. Williams & Wilkins Co., Baltimore, 1937. Cloth, 6 × 9 in., 216 pp., diagrams, tables, $2. The author of "Queen of the Sciences" here shows that mathematics, in one sense queen, is also the servant of the sciences. He explains and demonstrates the usefulness of such concepts as conic sections, fourth and higher dimensions, continuity and discreteness, chance and probability. The presentation is such that the reader with little technical knowledge may enjoy the book with a little judicious skipping.

HARDNESS OF METALS. By F. C. Lea. Charles Griffin & Co., Ltd., London. J. B. Lippincott Co., Philadelphia, 1936. Cloth, 6 × 9 in., 141 pp., illus., diagrams, charts, tables, cloth, $6. The principal object of this book is to establish the empirical relationship among various hardness-testing methods. The methods are described, the relation between hardness and certain other properties is discussed, and finally a general comparison of the results of a long series of tests is given

as a simple nomogram. A chapter on the hardness of rocks and like substances is included.

HEIMISCHE WERKSTOFFE FÜR WARMWASSERBEREITER FÜR EINZELHEIZUNG mit Kohle, Gas, Elektrizität. By M. Mengeringhausen. V.D.I. Verlag, Berlin, 1937. Paper, 6 × 8 in., 73 pp., illus., diagrams, charts, tables, 3.50 rm. This pamphlet discusses substitutes for copper in the manufacture of hot-water tanks, and is intended primarily to promote the saving of imported material in Germany. The possibilities of high-strength copper, rustless steel, glass, porcelain, galvanized and enameled iron, etc., are also considered.

HEROES OF THE AIR. By C. Fraser. Revised edition. Thomas Y. Crowell, New York, 1937. Cloth, 6 × 8 in., 786 pp., maps, $2.50. In this annually revised volume, after a brief survey of the development of aviation and aircraft to the time of the world war, the subsequent progress has been indicated by describing noteworthy flights which have taken place and the persons who performed them. Airplanes, dirigibles and stratosphere balloons are all considered. This graphic method of treatment, including simple maps, is a boon to the inveterate fact-gatherer.

(The) IDENTITY THEORY. By B. Stevens. Second edition, revised and enlarged. Sherratt & Hughes, Manchester, England; G. E. Stechert & Co., New York, 1936. Cloth, 6 × 9 in., 243 + 16 pp., diagrams, tables, 7s 6d. This book presents a mathematical theory of space-time relations as applied to the universe. The fundamental assumption is that, by means of three basic sets of signs and dimensions (time, space, inertia), all phenomena may be expressed as identities or equalities. The text is divided into articles, each one presenting a single deductive or inductive argument. The reader is assumed to have the "necessary" mathematical training, and a glossary and two tables of constants (accepted physical constants and estimated "identic" constants) are included.

INDEX TO A.S.T.M. STANDARDS AND TENTATIVE STANDARDS, January 1, 1937. American Society for Testing Materials, Philadelphia, Pa. Paper, 6 × 9 in., 118 pp., gratis. This index enables the user to ascertain readily whether the Society has issued standard or tentative standards, test methods or definitions upon any engineering material or subject, and to locate the volume in which the latest information will be found.

INSTRUMENT TRANSFORMERS. By B. Hague. Sir Isaac Pitman & Sons, London; Pitman Publishing Corporation, New York, 1936. Cloth, 6 × 9 in., 656 pp., illus., diagrams, charts, tables, $10. This book is, practically speaking, an extensive summary of hundreds of papers and magazine articles, with the object of giving a general view of the complete field covering theory, construction, characteristic features, and testing of instrument transformers. Certain specific phases and unusual types are omitted, being adequately covered elsewhere. Problems of practical design are not considered except in cases where the literature is scanty. In connection with the material on testing, various national and international rules for performance standards have been discussed. A full and closely subdivided subject index adds to ease in using the book for reference.

AUTHORS *and* PAPERS

MIXED with the varied diet of this month's offering of technical fare are three papers to be delivered at the 1937 Semi-Annual Meeting, Detroit, Mich., May 17 to 21, of The American Society of Mechanical Engineers.

MASS-PRODUCTION BEARINGS

It is not so many years ago that the mass production of bearings would have been looked upon with skepticism. Fitting each bearing to its own journal by painstaking scraping or careful lapping and running-in were almost inevitable procedures, and even with these precautions automobile owners were warned not to drive fast for the first thousand miles so that bearings could be broken in easily to their vital functions. But modern methods and machinery have changed all that, as ALBERT B. WILLI reminds readers in his paper, "Automotive Practice Influences Industrial Bearing Design." Mr. Willi grew up in the automobile industry which he served in various capacities for seventeen years. Starting as a draftsman he progressed through the various phases of engineering work pertaining to the design of internal-combustion engines with the Continental Motors Corporation, including the positions of chief draftsman, assistant chief engineer, and executive engineer. In 1934 he became associated with the Federal-Mogul Corporation and was soon thereafter appointed its chief engineer, the position he now holds. He is a member of the A.S.M.E.

SURFACE BROACHING

Surface broaching is an ancient process which the automobile and other mass-production industries have developed rapidly in recent years with the availability of suitable machines and broaching tools provided by the alert machine-tool industry. In the fields to which it is applicable surface broaching is, to a large extent, replacing other machining methods, and, as a result will undoubtedly stimulate improvement in the methods it is now replacing, such being the nature of the cycle of competition.

Reviewing recent developments in this remarkable machine-stop technique, SOL EINSTEIN and MILLARD ROMAINE, in a paper entitled "Surface Broaching in High-Production Industries," describe many types of surface-broaching machines and a number of examples showing the variety of jobs to which it is applied.

Mr. Einstein, a member of the A.S.M.E. for nearly a quarter century, is vice-president and chief engineer of the Cincinnati Milling Machine Company, of Cincinnati, Ohio, manufacturers of surface-broaching machines. Educated at the Technical University of Darmstadt, he came to this country in 1903 and commenced his work with his present employers in 1904.

Millard Romaine is a graduate of the class of 1918 of the University of Cincinnati, noted for its pioneering in "cooperative" education and for the men it has trained for the machine industries. He has been employed by the Cincinnati Milling Machine Company since graduation in various engineering capacities, and is at present in charge of its sales-engineering department.

POWER FOR DETROIT

An abundant source of reliable power is a *sine qua non* of such an industrial center as Detroit, and to serve such a district demands engineering and commercial skill of the highest order. It is typical of this country that industrialists have come to rely almost completely on large central stations whose managements and engineering staffs relieve manufacturers of much of the expense and worry of power problems.

Serving such a community as Detroit has greatly influenced the development of Detroit's central-station system and has impressed upon it some of its most salient features. In the paper entitled "Pooling Power in a Large Industrial Area Center," the authors show how The Detroit Edison Company has provided reserve capacity against the various exigencies of power-plant operation, and against outages occasioned by routine maintenance and excess capacity to meet the unpredictable and sudden demands of a vigorously expanding industrial community.

JAMES W. PARKER, coauthor of the paper with R. E. GREENE, is well known to readers of MECHANICAL ENGINEERING for his many services to the A.S.M.E. Vice-president and chief engineer of The Detroit Edison Company, he was graduated from Cornell in 1908. Since 1910, after two years spent successively with the DeKalb Power and Light Company and the Vincennes Street Railway, he has risen steadily in responsible positions with The Detroit Edison Company. During the War he was consulting engineer in the Nitrate Division of the Ordnance Department.

Mr. Greene is a graduate of the Worcester Polytechnic Institute, in electrical engineering, of the class of 1917. After two years in the U. S. Navy he entered the Testing Department of the General Electric Company, Schenectady, N. Y., and, in 1920, was transferred to the Central Station Engineering Department of that company. He became associated with The Detroit Edison Company in 1926 and in 1930 was made a senior engineer of the engineering division, the position he now holds.

CONDITIONING PERISHABLES

In a brief abstract of a paper on "Conditioning Fruits and Vegetables," J. E. MITCHELL tells some recent developments in reducing existing losses from mold and decay and in eliminating the shipment by rail of unripe produce. He describes a portable refrigerating and conditioning equipment used to remove

surface moisture from fruit and other perishable produce, prior to shipment, and of its uses in the rapid ripening of tomatoes.

Mr. Mitchell, who is a native of Chicago, has spent most of his life in Florida. He was graduated in 1936 from the University of Florida and is now engaged in conditioning citrus fruit in and around Haines City for the Produce Conditioners, Inc., of Miami, Florida.

REDUCING ERRORS IN GAS-TEMPERATURE MEASUREMENT

Accurate measurement of gas temperatures, as every one who has tried it will admit, is fraught with annoyance arising from radiation effects. A means of reducing the seriousness of these radiation errors is described in a brief article by W. L. SEVERINGHAUS, of Columbia University. Mr. Severinghaus was graduated in 1904 from the Baldwin Wallace College, and there in 1905 he received a master-of-arts degree. At Columbia, where he received his Ph.D. in 1914, he has served in the department of physics, and is now an associate professor in that department. Since 1929 he has been secretary of the American Physical Society.

AN ENGINEER'S RECOLLECTIONS

For many an elder reader of MECHANICAL ENGINEERING, ALBERT MILMOW's informal story of his early experiences as an engineer in foreign lands with little but his native ingenuity to guide him out of unexpected difficulties will bring back memories of anxious and exciting days. While few of our younger readers have had to wield a file and chipping hammer thousands of miles from a machine shop, they will, if they have the blood of real engineers in their veins, be quite as fascinated by Mr. Milmow's experiences as was the audience at the Charlotte Section of the A.S.M.E. to whom they were told last fall. Mr. Milmow was born in England, was brought to this country at the age of three, and lived during his boyhood in the hills of Tennessee in a colony founded by Thomas Hughes. author of "Tom Brown's School-days." Many of his early engineering experiences are told in his paper. For the last 14 years he has conducted his own sales-engineering practice at Charlotte, N. C., and at present represents a number of electrical manufacturers. He has recently been engaged in design and sales development in connection with the air cooling of homes, proving that he still retains the pioneer instinct.

HYDRO POWER

Popular and even engineering fancy is always aroused by water-power developments. The layman finds it hard not to believe that hydroelectric power costs nothing because Nature provides the rains that fill the lakes and rivers. Engineers are fascinated by the endless variety of technical problems presented by every new development. In a paper presented to the A.S.M.E. Los Angeles Section, R. R. ROBERTSON reviews some of the principal factors involved in the "Hydraulic Generation of Power" and says something about hydroelectric power costs.

Mr. Robertson, who is engineer of construction with the Los Angeles Bureau of Power and Light, is a Purdue graduate of the class of 1907, a class that has produced one A.S.M.E. president and an unusual number of A.S.M.E. Council and committee members. For several years after graduation he was associated with the Isthmian Canal Commission in Panama, but in 1912 he entered the Los Angeles Bureau of Power and Light, a career which was interrupted from 1917 to 1919 by the War. From 1933 to 1936 he was in charge of the construction of the Boulder Canyon Transmission Line which brings Boulder Dam electricity to Los Angeles. He has been a member of the A.S.M.E. since 1919.

RUBBER SPRINGS

With developments in rubber technology, and the knowledge of how to make a fast bond between metal and rubber, the use of rubber for springs and other shock-absorbing devices has been gaining headway. The physical properties of rubber and its use in tension, compression, and shear were described at the 1936 A.S.M.E. Annual Meeting by WALTER C. KEYS, in a paper published in this issue under the title, "Rubber Springs."

Mr. Keys, a University of Michigan graduate of the class of 1907 in electrical engineering, has spent much of his life with motor manufacturers, including Buick, Cadillac, and Chalmers. In 1913 he was assistant chassis engineer for Cadillac and four years later became mechanical engineer for the Perfection Spring Co. From there on he was successively with Standard Parts Co., Eaton Axle Co., and Gabriel Snubber Co. He next accepted the position of chief engineer of the automotive department, United States Rubber Co., and later became mechanical product engineer of the United States Rubber Products, Inc., the position he now holds. His work has been in the design and application of structural rubber, and he has played an important part in the standardization work of the Society of Automotive Engineers. He became a member of the A.S.M.E. in 1918.

ENGINEERING EDUCATION

Get any number of engineers together to discuss engineering education and you will find at least as many views as you have men. At the 1936 A.S.M.E. Annual Meeting three engineers were involved in a formal discussion of the subject and many more joined in informally. Briefly, Mr. Carrier is dissatisfied with the engineering student's ability to think, Mr. Funk is disturbed because principles taught in several courses are not carried over from one to the other in a realistic manner, and Professor Croft is concerned about the growing tendency of secondary schools to lower requirements and standards. Their more detailed views are presented in three papers under the general heading, "Engineering Education."

WILLIS H. CARRIER, as every one knows, is the father of air-conditioning in this country. Early in his career he taught school, and his first interests in science were gained largely by self study. He is a graduate of Cornell and has spent most of his professional career in developing air conditioning.

NEVIN E. FUNK, in charge of engineering for the Philadelphia Electric Company, was graduated from Lehigh in electrical engineering in 1905. Having spent a year teaching at the Georgia School of Technology and having had under him many graduates of engineering schools, his views on education have a practical basis.

HUBER O. CROFT is head of the department of Mechanical Engineering at the University of Iowa. His engineering education was acquired at the University of Colorado and the University of Illinois. Besides teaching at Iowa he has also taught at Illinois and Stanford.

All of these authors are members of the A.S.M.E.

GAS LIFTING OF OIL

It is not often that MECHANICAL ENGINEERING is able to publish an engineering paper relating to the petroleum industry, but the problem discussed in the paper "Producing Oil by Gas-Lift and Natural-Flow Methods," has a distinctly mechanical engineering flavor. When wells cease to flow naturally, production can be increased by the gas-lift method, and this the author describes.

S. F. SHAW, author of the paper, is a consulting engineer at Oklahoma City, Okla., who graduated from Columbia in 1905. He served as a mining engineer on various properties in Mexico, Central America, and the United States, and since 1926 has been consultant for various oil companies and has made trips to Colombia, Peru, Rumania, and Poland for the Standard Oil Company of New Jersey in connection with the gas lifting of oil. For the last five years he has engaged in general practice as a consultant, specializing in gas lifting.

RICE IRRIGATION

The brief abstract of a paper on a "Modern Rice-Irrigation System" describes a recent development in Orange County, southeastern Texas, and tests that were made of the Diesel-engine-driven screw pumps provided for that project. The author, WILLIAM B. GREGORY, professor of experimental engineering at Tulane University since 1905, is a Cornell graduate. He is widely known among engineers as an authority on low-lift pumps for drainage and dredging work in the lower Mississippi Valley. He has served as a consulting engineer to the Mississippi River Commission and the Army Engineer Corps. As a member of the A.S. M.E. since 1895 he has served on its Council as manager and vice-president, and has been president of the Louisiana Engineering Society.

INVESTMENTS

F. E. ARMSTRONG is a member of the department of economics and social science of the Massachusetts Institute of Technology which he entered in 1916 and which he has served as professor of political economy since 1926. He has been identified with the development of the course in engineering administration at M.I.T. and in corporate organization and finance, and public utilities and investment. The title of his review is "The Problem of Investment."

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Detroit Ready to Greet A.S.M.E.

1937 Semi-Annual Meeting Program Features General Sessions Technical Papers, and Plant Visits, May 17 to 21

AS THE current issue of MECHANICAL ENGINEERING goes to press the program of the 1937 Semi-Annual Meeting of The American Society of Mechanical Engineers, to be held at Detroit, Mich., May 17 to 21, with headquarters at the Hotel Statler, becomes sufficiently concrete to be announced in essential details.

For months the Detroit Committee, the Society's Meeting and Program committee, its professional divisions, and the authors of the technical papers have been at work preparing a schedule of meetings and events that will attract engineers from all over the country. Building around the major interest of Detroit, the automotive industry, the committees have sought to unify the major contributions by setting up as a keynote what modern techniques in the mass-production industries, as typified in the manufacture of automobiles, have meant to mechanical engineering in general. To this end a planned program of six general sessions which has been developed, will be introduced by C. F. Hirshfeld at Tuesday morning's session, and at the dinner on Thursday, Willard T. Chevalier will summarize the weeks' program and its significance. Of the six general sessions, two, in addition to the banquet, will be held in the evening so that engineers compelled to stay at their work during the day may participate.

National Figures as Speakers

The local committee has drawn upon national figures in the automotive field in providing speakers for these general sessions, and has arranged for a technical, as well as a more general, paper at each of them. In order to avoid conflict with attendance at the general sessions, papers contributed by the professional divisions to be presented at simultaneous sessions have been scheduled for the afternoons and for Friday morning.

On Monday, in addition to an all-day meeting of the A.S.M.E. Council, major inspection tours have been arranged for the afternoon, and for the convenience of those who cannot take part in Monday's tours, others will be held on Friday morning. Throughout the week other trips to local plants will be offered so that all visitors may have an opportunity of seeing Detroit's industries as well as attending the A.S.M.E. meeting. Special events have been arranged for the women, although they will find most of the general sessions and some of the technical plant visits of interest to them also.

In addition to the speakers at the general sessions already mentioned, visitors will have an opportunity to hear William S. Knudsen, executive vice-president of the General Motors Corporation, Edward G. Budd, of the Edward G. Budd Manufacturing Co., W. J. Cameron, of the Ford Motor Company, and T. F. Olt, supervising metallurgical engineer of the American Rolling Mill Company.

C. F. Hirshfeld to Give Keynote Address

At Tuesday morning's general session, with James H. Herron, president of the Society presiding, Mr. Hirshfeld's keynote address will be followed by a paper on modern locomotive- and axle-testing equipment, by Tracy V. Buckwalter, vice-president, O. J. Horger, research engineer, and W. C. Sanders, general manager, railway division, of the Timken Roller Bearing Company.

Mr. Knudsen's address on Tuesday evening will be accompanied by a paper on contribution of the machine-tool builders to the mass production of automobiles, by Fred W. Cederleaf, manager of the machinery division of the Ex-Cell-O Aircraft and Tool Company. On Thursday morning, which will be devoted to the subject of lightweight trains, Rupen Eksergian, of the Edward G. Budd Manufacturing Co., will follow Mr. Budd in a discussion of the economics of power for lightweight trains. The fourth general session, on management and mass-production methods, held on Wednesday evening, will provide an opportunity to hear not only Mr. Cameron but also John W. Scoville, chief statistician of Chrysler Corporation, who will speak on "Charting the Business Course in Navigating the Automotive Industry."

Mr. Olt's paper, at the fifth general session on Thursday morning, which will discuss production and quality control of sheets for autobody fabrication, will be followed by a companion paper by J. E. Angle, assistant general superintendent, Sheet and Tin Mills, Chicago District, and W. F. McGarrity, strip metallurgist, Pittsburgh District, of the Carnegie-Illinois Steel Corporation, entitled "Metallurgical Aspects of Hot and Cold Strip for Deep-Forming Requirements."

President Herron to Preside at General Sessions

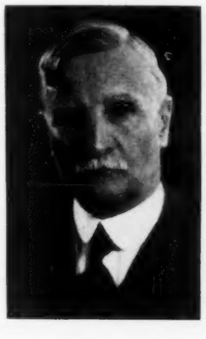
At all of the general sessions, President Herron will preside. President Herron will also act as toastmaster at the Thursday evening banquet and will speak on that occasion on A.S.M.E. affairs.

For the simultaneous sessions scheduled for Tuesday, Wednesday, and Thursday afternoons and Friday morning, technical papers will be offered on economics, hydraulics, power, fuels, machine-shop practice, rubber, welding, condensers, relations with colleges, materials handling, petroleum, impact testing, apprentice systems, cutting-metals research, railroads, Diesel engines, transportation, and


W. S. KNUDSEN


W. T. CHEVALIER


J. H. HERRON

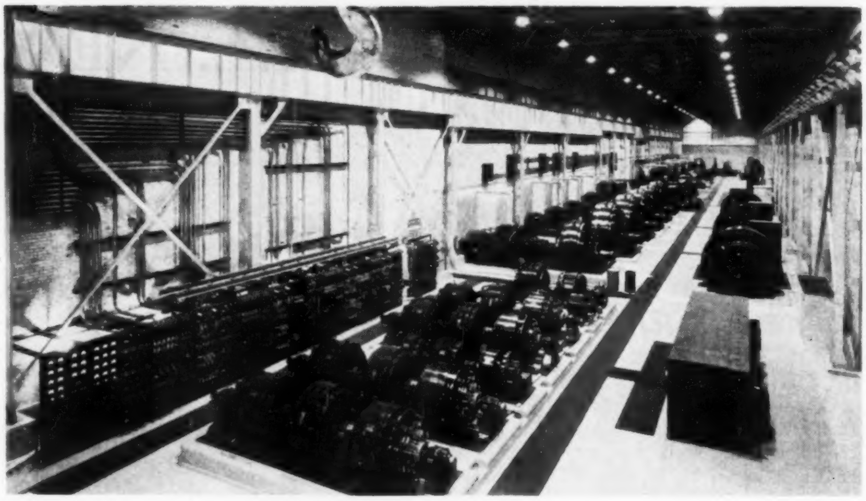

E. G. BUDD


C. F. HIRSHFELD

SPEAKERS AT THE GENERAL SESSIONS

streamlining, under the auspices of the Society's professional divisions. Many meetings of technical committees are also provided in the program.

Many of the technical papers will be found in this and other issues of MECHANICAL ENGINEERING or in the Transactions for April and May. Some papers for which manuscripts were not received in time for prepublication will be available at the meeting. Most of the more general papers and addresses will probably be published in later issues of MECHANICAL ENGINEERING and the Transactions. In the program which follows an attempt has been made to indicate where papers already published may be found.



GENERAL VIEW OF MOTOR ROOM FOR 96 IN. STRIP MILL, GREAT LAKES STEEL PLANT, ECORSE

Tentative Program

SUNDAY, MAY 16

10:00 a.m.

Meeting of Executive Committee of Council
Meeting of Committee on Local Sections

MONDAY, MAY 17

8:30 a.m.

Registration starts, Ballroom Floor Lobby, continuing all week
Sale of inspection-tours tickets
Registration for women's events
Ladies' parlor open
Nominating Committee meets

9:30 a.m.

Council Meeting, followed by luncheon

1:00 p.m.

Women's special afternoon tour of Ford Rouge River Plant

1:15 p.m.

Men's simultaneous inspection tours to Conners Creek Power Plant, or Edison Institute Museum and Village, or Ford River Rouge Plant

2:00 p.m.

Council Meeting, continued

6:30 p.m.

Council Dinner

8:00 p.m.

Business Meeting

Ladies visit Radio Studios WWJ

Registration

THERE will be no registration fee for the Semi-Annual Meeting at Detroit, but registration will be extended to nonmember engineers only on the written request of an A.S.M.E. member made in advance of the meeting. Requests should be sent to James W. Armour, chairman of the Registration and Reception Committee, whose address is Riley Stoker Corporation, Foot of Walker St., Detroit, Mich.

TUESDAY, MAY 18

8:15 a.m.

Authors' breakfast with President and Vice-Chairman

9:30 a.m. General Session-1

KEYNOTE ADDRESS
The Scope and Purpose of the Planned Program
Historical Sketch Contrasting the Practice of Automotive Design and Production With Methods in Older Engineering Fields, both by C. F. Hirshfeld
Modern Locomotive and Axle-Testing Equipment, by Tracy V. Buckwalter, W. C. Sanders, and O. J. Horger[1]

10:00 a.m.

Women's inspection tour to Edison Institute (Dearborn) starts from Hotel Statler

12:30 p.m.

Authors' luncheon with Chairman

1:30 p.m. Hydraulics and Power

The Springwells Station of the Detroit Department of Water Supply, by W. C. Rudd and B. J. Mullen
Followed by inspection tour through station

2:00 p.m. Economics

Economic Characteristics of Typical Business Enterprises, by Walter Rautenstrauch[1]

2:00 p.m. Fuels

The Separation and Emission of Cinders and Fly Ash, by Arthur C. Stern[2]
Incinerators—Municipal, Industrial, and Domestic, by H. S. Hersey[2]
Industrial Heating and Process Furnaces, by E. F. Holser

2:00 p.m. Machine Shop Practice

Surface Broaching in High-Production Industries, by Sol Einstein and Millard Romaine[3]
Automotive Practice Influences Industrial Bearing Design, by A. B. Willi[3]

[1] Published in A.S.M.E. Transactions for April, 1937.
[2] To be published in A.S.M.E. Transactions for May, 1937.

2:00 p.m. Rubber

Rubber-Cushioning Devices, by C. F. Hirshfeld and E. H. Piron

6:30 p.m.

Authors' dinner with President and Vice-Chairman

8:00 p.m. General Session-2

Jointly with American Society of Tool Engineers

Recent Developments in the Basic Processes of Fabrication, viz., Casting, Forging, Welding, Machining, Pressing, and Rolling, with Social and Economic Implications, by William S. Knudsen
Outstanding Contributions Made by the Machine-Tool Builders to the Art of Building Automobiles on Mass-Production Lines, by Fred W. Cederleaf

WEDNESDAY, MAY 19

8:15 a.m.

Authors' breakfast with President and Vice-Chairman

9:30 a.m. General Session-3

The Aspects of Automotive Engineering Applicable to Railroading, by E. G. Budd
The Economics of Power for Lightweight Trains, by Rupen Eksergian

11:00 a.m.

Women's inspection tour leaves Hotel Statler for Cranbrook Foundation

12:30 p.m.

Authors' luncheon with Chairman

1:15 p.m.

Men's inspection tour starts from Hotel Statler for Ex-Cell-O Aircraft & Tool Corp. See also Materials Handling Session tours

[3] Published in this issue.

VISIT PLANNED TO CRANFORD SCHOOL FOR BOYS

1:30 p.m. Materials Handling

Descriptive lectures and tours to Plymouth Assembly Line or Chevrolet Forge

2:00 p.m. Welding

Jointly with American Welding Society

Welded Steel in High-Speed Railway Service, by Everett Chapman

Hydromatic Welding of Frames, by C. L. Eksergian

2:00 p.m. Condensers

The Prevention of Failures of Surface-Condenser Tubes, by Robert E. Dillon, George C. Eaton, and H. Peters[1]

The Condensation of Flowing Steam, by John I. Yellott and C. Kenneth Holland[1]

2:00 p.m. Fuels

The Forced-Draft Spreader Stokers, by J. F. Barkley; followed by panel discussion.

2:00 p.m. Relations With Colleges

The Automobile Industry and Young Engineers, by C. J. Freund[4]

2:00 p.m. Lubrication

Apparatus and Test Results on Dry Friction; Various Materials and Comparisons With Other Data, by W. E. Campbell

Oil-Film Thickness at Transition From Semi-Fluid to Viscous Lubrication, by G. B. Karelitz and J. N. Kenyon[1]

4:00 p.m. Petroleum

The Petroleum Industry in Michigan, by C. R. Miller

6:30 p.m.

Authors' dinner with President and Vice-Chairman

[4] Published in Mechanical Engineering for April, 1937.

8:00 p.m. General Session-4

Charting the Business Course for Navigating the Automotive Industry, by John W. Scoville

The Decentralization of Industry, by W. J. Cameron

THURSDAY, MAY 20

8:15 a.m.

Authors' breakfast with President and Vice-Chairman

9:30 a.m. General Session-5

Production and Quality Control of Sheets for Automobile-Body Fabrication, by T. F. Olt[1]

Metallurgical Aspects of Hot and Cold Strip for Deep-Drawing Requirements, by J. E. Angle and W. F. McGarrity

10:00 a.m.

Women's sight-seeing tour leaves Hotel Statler for Lake Shore Drive, etc., and afternoon bridge party at Detroit Yacht Club

12:30 p.m.

Authors' luncheon with Chairmen

1:15 p.m.

Men's simultaneous inspection tours start from Hotel Statler for Edison Institute Museum and Village, or Dodge Bros. Corp. Body Plant, or U. S. Rubber Company

2:00 p.m. Iron and Steel

Application of Tension Impact Tests, by Glen F. Jenks

2:00 p.m. Apprenticeship

A Year of the New Apprenticeship in the Detroit Industries, by Chester W. Culver

Organization and Purposes of the Future Craftsmen of America, by J. Lee Barrett

2:00 p.m. Cutting-Metals Research

A Study of Lip Clearance on Twist Drills, by Charles J. Starr[1]

Grinding of Cemented-Carbide Milling Cutters, by Hans Ernst[4]

The Effective Use of Metal-Cutting Tools, by R. C. Deale

2:00 p.m. Power

Pooling Power in a Large Industrial Center, by J. W. Parker and R. E. Greene[3]

Analysis and Tests on Hydraulic Circuits of Surface Condensers, by G. H. Van Hengel[1]

2:00 p.m. Railroad

Maintenance of High-Speed Diesel Engine on the Canadian National Railways, by I. I. Sylvester[2]

Electricity in Transportation

7:00 p.m. General Session-6

Dinner Meeting

James H. Herron, President A.S.M.E. to speak on
Summary of Week's Program and Its Implications
Society Affairs

Principal Speaker, Col. Willard T. Chevalier

Awards: Dr. Alex Dow, Honorary Membership in A.S.M.E.

Informal Reception and Dance

FRIDAY, MAY 21

8:15 a.m.

Authors' breakfast with Chairmen

8:45 a.m.

Men's simultaneous inspection tours to Conners Creek Power Plant of The Detroit Edison Company, or to the plant of the Great Lakes Steel Corporation. These tours will be conducted jointly with Cleveland Engineering Society

9:30 a.m. Power

Operating Experiences in the Steam and Power Department of the South's First Alkali Plant, by G. R. Avery

Formulas for Stresses in Bolted Flanged Connections, by Everett O. Waters, D. B. Wesstrom, D. B. Rossheim, and F. S. G. Williams[1]

Railroad Arrangements for Semi-Annual Meeting at Detroit, May 17-21, 1937

No special convention rates are obtainable from the railroads for meetings. Therefore your reservations should be made early through your own railroad agent. Special A.S.M.E. cars will be run from points in the East and it will be well to ask about them when purchasing your ticket.

On Sunday, May 16, special A.S.M.E. cars will be attached to "The Detroiter," on the New York Central, leaving New York City at 7:45 p.m. daylight saving time; and to "The Red Arrow," on the Pennsylvania, leaving New York at 5:37 p.m., daylight saving time. Connections for these special cars may also be made on "The Red Arrow" leaving Washington at 4:40 p.m., eastern standard time; Baltimore at 5:28 p.m.; and Pittsburgh at 1:42 a.m., May 17.

The fare from New York to Detroit, one way, in a Pullman car, is $21.50; Lowers are $4.25; bedrooms, single or double, $7.65.

9:30 a.m. Railroad

Air Resistance of Railway Equipment, by A. I. Lipetz

Lightweight Passenger-Train Resistance, by A. I. Totten[2]

12:45 p.m.

Luncheon in Ballroom, Dearborn Inn. Price $1.25 per person

2:00 p.m.

Men's simultaneous inspection tours leave for Ford Rouge Plant, Power Plant and Assembly Line, or Steel Mill and Assembly Line, or Glass Mill and Assembly Line

4:30 p.m.

Ford Rotunda

5:00 p.m.

Return to Hotel Statler

Women's Program

MONDAY, MAY 17

All Day

Registration to obtain A.S.M.E. Identification Badge

Ladies' Parlor Open, Ballroom Floor, Hotel Statler

1:00 p.m.

Assemble at Hotel Statler, Bagley Avenue entrance

2:00 p.m.

Visit Ford Rotunda to see photomurals and model exhibits

Drive to Ford Rouge Plant in Ford busses, visit machine shops and assembly line. Party will be conducted by Ford guides along a route interesting to women and easily accessible

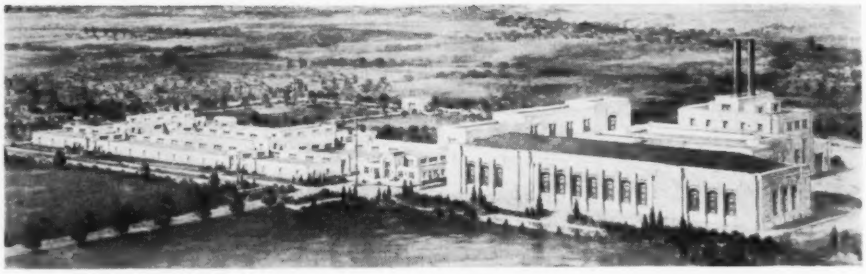
5:00 p.m.

Return to Rotunda to take A.S.M.E. busses back to Hotel Statler, arriving between 5:45 and 6:00 p.m.

8:00 p.m.

Assemble at Hotel Statler, west entrance

BELLE ISLE, DETROIT



SPRINGWELLS STATION OF DETROIT WATER SUPPLY

(Paper on "The Springwells Station of the Detroit Department of Water Supply" to be presented Tuesday afternoon by W. C. Rudd and B. J. Mullen.)

8:30 p.m.

Radio Station WWJ studio program

10:00 p.m.

Return to Hotel Statler, arriving about 10:15 p.m.

TUESDAY, MAY 18

Edison Institute Museum and Greenfield Village

$1.00 per person, including all expenses

9:45 a.m.

Assemble at Hotel Statler, Bagley Avenue entrance

11:00 a.m.

Visit Edison Institute Museum. Each party of about ten persons is conducted by a trained guide who describes exhibits of choice china, furniture, craftsmanship, and historical engineering and transportation equipment

12:30 p.m.

Take Ford busses to Dearborn Inn

1:00 p.m.

Luncheon in Ballroom, second floor. A.S.M.E. Trip Tickets will be collected during lunch

2:30 p.m.

Assemble in hotel lobby or court for visit to Greenfield Village; transportation by Ford busses

2:45 p.m.

Visit Greenfield Village to see Thomas A. Edison's laboratory and Menlo Park, Clinton Inn, Martha and Mary Chapel, Court House in which Abraham Lincoln practiced, Rose Cottage from Broadway, England; and numerous old-fashioned shops

5:00 p.m.

Return to Hotel Statler by A.S.M.E. busses, arriving about 6:00 p.m.

8:00 p.m.

Ladies invited to join General Session-2 to hear talk by William S. Knudsen, executive vice-president of General Motors Corporation

Ladies desiring to attend movies will find several first-class shows within easy walking distance of the hotel

WEDNESDAY, MAY 19

Oakland Hills Country Club and Cranbrook Foundation

$1.00 per person, including all expenses

10:45 a.m.

Assemble at Hotel Statler, Bagley Avenue entrance

Drive through suburban districts to Oakland Hills Country Club

12:00 m

Luncheon at Oakland Hills Country Club. A.S.M.E. Trip Tickets will be collected during lunch

1:15 p.m.

Take A.S.M.E. busses to Cranbrook Foundation

2:00 p.m.

Visit the Cranbrook Art School to see weaving and art studios, the Cranbrook School for Boys, the Kingswood School for Girls. The Cranbrook Foundation is noted for its architecture and landscaping. A brief carillon recital at Christ Church may be heard

5:00 p.m.

Return to Hotel Statler by A.S.M.E. busses, arriving about 6:00 p.m.

8:00 p.m.

Ladies invited to join General Session-4 to hear talk by W. J. Cameron of the Ford Motor Co. Mr. Cameron's brief talks featured on the Ford Sunday-Evening Hour are well known to radio listeners

Movie shows are within easy walking distance of the hotel

THURSDAY, MAY 20

Sight-Seeing Tour and Bridge Party

$1.00 per person, including all expenses

10:15 a.m.

Assemble at Hotel Statler, Bagley Avenue entrance

Drive through residential districts to Grosse Pointe; Lake St. Clair Shores, and return

to Belle Isle. Time permitting, a brief stop may be made at the Russell A. Alger Museum of Italian Renaissance Art

1:00 p.m.

Luncheon at the Detroit Yacht Club. A.S.M.E. Trip Tickets will be collected during lunch

2:30 p.m.

Ladies' Bridge Party, Door and Table Prizes. Use of Club's lounge and veranda overlooking Detroit River

4:30 p.m.

Return to Hotel Statler by A.S.M.E. busses arriving about 5:15 p.m.

7:00 p.m.

Dinner meeting, General Session-6 (informal)
Speakers: President James H. Herron
Col. Willard T. Chevalier
Presentation of honorary membership to Dr. Alex Dow
Reception and dancing

FRIDAY, MAY 21

No Engagements Scheduled

Visitors may inspect the Detroit Shopping Center, The Institute of Art and Public Library, etc.
Detroit ladies will join groups of visitors upon request, should they desire conducted tours.

Instruments and Regulators Committee to Meet

THE Subcommittee on Industrial Instruments and Regulators of the A.S.M.E. Process Industries Division will have an all-day open session on May 17 at the Hotel Statler, Detroit, during the Semi-Annual Meeting of the Society. The scope of the work of the committee and a report on terminology from a subgroup are to be considered.

There will also be a discussion of papers and other material for presentation in symposium form at the 1937 Annual Meeting. Anyone wishing to have such material considered at the Detroit meeting is requested to send a copy to the secretary, A. F. Spitzglass, 2240 Diversey Parkway, Chicago, Ill.

Wood Industries Division Plans Fall Meeting

THE Wood Industries Division of the A.S.M.E. will hold a two-day meeting late in October of this year at Grand Rapids, Mich., at which it is planned to present papers and discussion of manufacturing costs in the industry, and on the machining of wood. It is expected that a paper will be given by a member of the staff of the U. S. Forest Products Laboratory concerning the experiments they have made in the planing of 25 wood species under a variety of conditions.

National Rayon Textile Conference, Washington, D. C., May 14–15

Howard Ketchum Speaker at Dinner; Harrison E. Howe, Toastmaster

HOWARD KETCHUM

COOPERATING in the National Rayon Textile Conference to be held in Washington, D. C., May 14 and 15, are the Textile Division and Washington Section of the A.S.M.E., the American Association of Textile Chemists and Colorists, Committee D-13 of the American Society for Testing Materials, the United States Institute of Textile Research, and the Throwsters Research Institute.

The Conference will bring together engineers, chemists, and other technicians and permit each group to learn what the others are doing toward the solution of problems involved in the manufacture and processing of rayon yarns and fabrics. It is believed that from this interchange of experiences the way will be paved for further and more rapid progress in these directions.

All sessions of the Conference will be held at the Bureau of Standards. There will be a registration fee of $5 which will also include the cost of the dinner to be held on Friday evening at the Wardman Park Hotel. At this dinner which will be an informal one, Howard Ketchum will be the principal speaker, and Dr. Harrison E. Howe, the toastmaster.

Other features of the program include moving pictures showing the manufacture and finishing of rayon and the finishing of rayon fabrics, and a visit to the textile laboratories of the National Bureau of Standards.

Headquarters of the conference will be at the Wardman Park Hotel.

The tentative program for the technical sessions which are to be held in the lecture room on the fourth floor, East Building, of the National Bureau of Standards is as follows:

FRIDAY, MAY 14

9:00 a.m.

Presiding Officer: C. H. Ramsey

Address of Welcome to be delivered by M. X. Wilberding, Chairman, Washington Section, A.S.M.E.
Air Conditioning of Textile Plants Making and Using Synthetic Rayon, by L. L. Lewis, chief engineer, Carrier Engineering Corporation
The Mechanics of Synthetic Fiber Weaving, by Albert Palmer, assistant to general manager of the Crompton & Knowles Loom Works

1:30 p.m.

Presiding Officer: Lewis A. Olney, of the American Association of Textile Chemists and Colorists
Cause of Rayon Crepe Variations with Special Reference to Throwing, by John Macia, research fellow, A.S.T.C.C. and Throwsters Research Institute
Effect of Embossing and Boil-Off on Finished Crepe Fabrics, by James McGibbon, North American Rayon Company

7:00 p.m.

Informal Dinner at the Wardman Park Hotel

Presiding Officer: M. X. Wilberding

Toastmaster: Harrison E. Howe, Editor, *Industrial and Engineering Chemistry*

Speaker: Howard Ketchum who will have for his subject "Color Comes of Age."

Motion pictures will be shown on rayon production and finishing through the courtesy of the Viscose Company

SATURDAY, MAY 15

9:00 a.m.

Presiding Officer: Herbert J. Ball
Testing of Rayon and Acetate Yarns and Fabrics, by E. Freedman, R. H. Macy & Company
Manufacture of Cut Rayon Staple, by F. Bonnet, Viscose Company
Stainless Steel and Its Application in the Textile and Rayon Industries, by G. W. Hinkle, metallurgist, Republic Steel Company

All textile men and others interested in the manufacture of rayon yarns and fabrics, whether or not they are members of any of the cosponsoring organizations, are cordially invited to attend the Conference and take part in the discussions. Details regarding hotel reservations, transportation, etc., may be obtained by writing to M. A. Golrick, Secretary, Textile Division, A.S.M.E., 29 West 39th Street, New York, N. Y.

Papers, Reports, and Diesel Exhibit for Oil and Gas Power Meeting

A COMPREHENSIVE program of valuable papers and reports is being planned for the meeting of the Oil and Gas Power Division of the A.S.M.E., August 18 to 21, at Pennsylvania State College, State College, Pa. An exhibit of new and interesting Diesel-plant accessories and engine parts will be on display during the meeting. The detailed program of papers and events will be published later.

Don't Lend Him the $5

A CONSULTING engineer in New York reports the following variation of the familiar "con" game, which some one tried out on him.

A man, who has apparently obtained information about you from a professional directory, calls you on the phone to say he is president of a company and is on his way to Washington with his son whom he is sending to you to discuss a report he wishes prepared on the power plant of his factory. The son arrives, chats pleasantly, seems anxious to set a date for you to visit the factory, and asks you to write his father at a Washington hotel to say when you can make the visit. Some time later he dashes back and asks if he has left a pocket notebook. He has lost it, and it contained five dollars, the only money he had to pay his fare back home. Can you lend him the five? Well, says our informant, don't. He did not, but checked up the name and address used and found them to be fictitious. He says the trick has been played on other engineers in New York.

What A.S.M.E. Local Sections Can Do

Résumé of Suggestions Offered in Letter From Local Sections Committee

FOR A majority of members of The American Society of Mechanical Engineers their local section is their closest contact with the Society as an organization. Realizing that, as a result of this close relationship, members have a keen interest in the administration of local-section affairs, the Committee on Local Sections has recently sent a letter to all executive committees of the sections in which it explains some of the immediate concerns of its work. The committee has also asked that wide publicity be given to this letter and a résumé of the parts of it that are of greatest general interest has been prepared in what follows.

Allotment of A.S.M.E. Section Funds

In the Society's "Manual for the Operation of a Local Section" appears a "formula" by means of which the allotment of funds to local sections is computed. This formula is as follows:

- $150 to each section plus $1.50 per member for the first 500 members of the section
- $1.25 per member for the second 500 members
- $1 per member for all over 1000 members
- No appropriation to exceed $3.50 per member.

Since the beginning of the depression the Council has been unable to appropriate enough money to meet the full amounts computed by means of the formula. For the current year, only 75 per cent of the formula amounts has been allotted. Although in January, 1937, because of increased Society income, the appropriation to the Local Sections Committee was increased by $2000, the total fund available is still $600 short of the amount that would be needed if every section requested 75 per cent of what is due it under the formula.

Under the Society's general financial policy, unexpended balances are placed in the reserve fund at the end of the year. However, in order to provide a working fund for each section, the return of unexpended section sums to the Society is not required, but if a section has an appreciable balance at the beginning of the fiscal year, this amount is deducted from the allotment paid to it for the second half of that year's operation.

Inasmuch as payments to a local section are made only when its existing balance is less than 25 per cent of its total allotment to which it is entitled during a fiscal year, they are not made unless current financial statements are filed at the secretary's office. Payments are due upon receipt of these statements on October 10 and February 10. Statements received later than these dates are acted upon semimonthly on the tenth and twenty fifth days of the month. By keeping these dates in mind annoying delays are avoided.

Sections planning to carry on unusual activities that require funds in excess of regular allotments must present their plans for approval by the Committee on Local Sections and must receive that approval before obligating themselves to expenditures. However, sections are not encouraged to plan for expenditures in excess of their allotments for a fiscal year.

Informal Conference at Detroit

If sufficient interest and volunteer attendance are guaranteed, an informal conference of sections' delegates will be held at the Semi-Annual Meeting in Detroit, on Wednesday, May 19, at 12 o'clock at the Hotel Statler. The conference is termed "informal" because traveling expenses are not paid and hence not every section will be represented. However, as has been shown by previous informal conferences, many subjects can be discussed with profit even though actions resulting

The Members' Page

A Forum for Frank Discussion by A.S.M.E. Members

A.S.M.E. Affairs

DEAR MR. BATT:

Accept my sincere appreciation of the splendid record that you and the Council presented to the membership in the January number of MECHANICAL ENGINEERING. The concise reports of the Council as to the state of the Society and the activities are conducive to a better understanding between our vastly widespread membership and the New York Headquarters.

In the past, especially during the years of duress, a large proportion of the members—those remote from New York—misunderstood the problems of the governing body but felt justified in their position that the Council was operating the Society in an autocratic atmosphere and that suggestions from the members were not welcomed. The writer feels that the January issue goes far to dispel this feeling and imbeds very firmly the idea that our Society is a very democratic one and that the success of our Society depends upon us and that our interests are looked after by our representatives. Only by free intercourse between the governing body and the membership at large can the highest contributions of the Society toward the members and Society be attained.

Your study of A.S.M.E. affairs is in accord with the sentiments and strikes a sympathetic cord, which will bring the members closer to New York. I was particularly interested in your comments on MECHANICAL ENGINEERING. In talking to a fair representation of members I have found that we are very much on the common ground. MECHANICAL ENGINEERING should minimize its articles on highly technical discussions and "liberalize" its articles with papers or mental pictures on accomplishments in broader horizons in mechanical engineering.

MECHANICAL ENGINEERING'S entrance into the field of free discussion in social-economic-engineering problems has received favorable comment. The review of books is also a valuable asset. Your idea of a "Readers Digest," has wonderful possibilities, so long as it is kept unbiased and presents two sides of all questions.

EDWARD C. BARKSTROM.[1]

[1] Chief Engineer, Design and Sales, Stephens-Adamson Manufacturing Co., Los Angeles, Calif. Mem. A.S.M.E.

therefrom cannot be considered as binding due to lack of full section representation. Sections are asked to see that a representative is at the conference if possible and to let the committee know whether or not a representative will be present.

Increased Junior Activities

The Committee is glad to report that more sections are organizing Junior Groups, and that those that have pursued this policy in recent years have been finding it more and more advantageous. It is hoped that the action, which the Committee has recommended will enable student members on graduation to accept their transfer to the Junior grade immediately by the payment of only one quarter of the annual dues, or $2.50, instead of a full year's payment, will not only bring a much larger number of these young engineers into section activity, but will cause all sections to establish opportunities through the Junior Groups for these younger men to hold meetings on the subjects in which they have particular interest.

Inactive Sections Liable to Suspension

At least half a dozen sections are under observation because of their lack of activity or weakened condition in number of members. The Committee believes that sections which have less than 15 members should be given a warning of suspension, and if they do not improve this condition within a reasonable time they should be suspended. The same action should be taken, it is felt, where sections do not hold at least two meetings annually.

Look Up the Student Branches

As spring arrives, local sections should renew their contacts with the student branches in their communities, encouraging them in their activities, particularly with regard to the student members who are about to be graduated. A feeling of real interest on the part of the parent Society and its desire to absorb these men as they are graduated into the ranks of the various sections where they may locate in their first job should be developed.

Membership Development

The Council has appointed a special committee on membership development, of which Past-President Dexter S. Kimball is chairman, with the object of encouraging qualified engineers to become members of the Society. Dean Kimball will be glad to assist in inaugurating membership-development activities, and sections desiring to make use of his advice and assistance should communicate with him.

Encourage Participation in Public Affairs

Every local section should encourage its members to participate in public and civic affairs in the communities of which the sections are a part. Such activities include active interest in engineering registration, the work of the Engineers' Council for Professional Development and the American Engineering Council.

National Meetings Being Planned

It is the hope of the Committees on Local Sections, Meetings and Program, and Professional Divisions that the Society will be able to hold four national meetings annually beginning this fall. With this in mind a policy has been proposed which would provide a meeting annually near the Pacific Coast, a meeting alternately in New England and in the South, and a meeting in the northeastern section of the country, i.e., east of the Mississippi and north of the Ohio, in addition to the Annual Meeting. Meetings in Detroit during the week of May 17, in Erie during the week of September 25, and the 1937 Annual Meeting at New York have been approved. Other meetings have been located tentatively with regard to a fair geographical distribution. In addition to these national meetings, which will be designated Annual, Semi-Annual, Spring, and Fall meetings, there is tentative provision for at least one meeting annually of each of the professional divisions. Both types of meetings are financed out of national and not local section funds. Sections interested in securing meetings for their localities should write to the Secretary.

Nominating Local Men for National Committees

The Secretary will appreciate nominations from every local section of members of the section who would be willing to serve on national committees, both of an administrative and of a technical character. It should be understood that in most cases these committeemen will have to attend meetings in other than their home cities without remuneration for traveling or other expenses. A number of members even at points distant from New York frequently visit that city for business or personal reasons and can, therefore, serve on national committees. It is desired to have as wide a geographical representation on all committees as is possible, consistent both with attendance and the necessary qualifications for service on any particular committee.

Cooperate With the Professional Divisions

It is suggested that each local section appoint a member to cooperate with each of the five departments into which the professional divisions have been grouped; i.e., basic science, power, manufacturing, management, and transportation. It is suggested also that each section report to the Secretary which of these departments it believes it can make contributions to. It is felt that every local section should be able to contribute at least one paper annually to some one of the 16 professional divisions of the Society. This paper could be delivered first before the local section and then submitted to the professional division within whose activity it comes for presentation at a national divisional meeting or one of the four national meetings of the Society. In this way, the local sections would contribute definitely and cooperate intimately with the professional divisions and be a source of enrichment of the Society's literature.

Program for Joint Meeting of Applied Mechanics and Hydraulic Divisions, Ithaca, June 25–26

Sessions on cavitation, vibration, fluid mechanics, elasticity, and plasticity, are planned for the fifth national meeting of the A.S.M.E. Applied Mechanics Division to be held jointly with the Hydraulic Division, at Cornell University, Ithaca, N. Y., June 25 and 26.

Papers as planned for these sessions are listed as follows:

FRIDAY, JUNE 25

Morning Cavitation

Determination of the Relative Resistance to Cavitation Erosion by the Vibratory Method, by S. Logan Kerr, United Engineers & Constructors, Inc., Philadelphia

Pitting Resistance on Metals Under Cavitation Conditions, by J. M. Mousson, Safe Harbor Water Power Corporation, Baltimore, Md.

Vibration

The Use of Rubber in Vibration Isolation, by E. H. Hull, General Electric Company

Rubber Mountings, by J. F. Downie Smith. E. G. Budd Company, Philadelphia, Pa.

Influence of Earthquakes Upon Buildings, by L. S. Jacobsen, University of California

2:00 p.m. Fluid Mechanics

Cavitation Testing of Marine Propellers, Lybrand P. Smith, U. S. Navy

Flow Through Granular Materials, B. A. Bakhmeteff and N. Feodoroff, Columbia University

Recent Developments of the Theory of Turbulence, H. L. Dryden, U. S. Bureau of Standards

A Theory for Sharp-Edged Orifices, by W. E. Howland, Purdue University*

SATURDAY, JUNE 26

9:00 a.m. Elasticity

Load-Deflection Characteristics of Initially Curved Flexural Springs, by W. E. Johnson, General Electric Company

Thermal and Assembly End Reactions and Stresses in Pipelines With Many Bends, by G. B. Karelitz, Columbia University

Working Stresses for Members Subjected to Fluctuating Loads, by Joseph Marin, Rutgers University

Torsion of Rectangular Tubes, by W. Hovgaard

(Program continued on following page)

* To be presented by title only.

Stress Systems in a Circular Disk Under Radial Forces, by Raymond D. Midlin, Columbia University*

The Calculation of Maximum Deflection, Moment, and Shear for a Uniformly Loaded Rectangular Plate with Clamped Edges, by I. A. Wojtaszak, University of Michigan*

On the Stability of a Clamped Elliptic Plate Under Uniform Compression, by S. Voinovsky-Krieger, Berlin*

Deflection of Beams of Variable Cross Section, by M. Hetenyi*

Paper on Two-Dimensional Problems, by Dr. Poritsky, General Electric Company*

2 p.m. Plasticity

Recent Investigations in Plastic Torsion, by C. W. MacGregor and J. A. Hrones, Massachusetts Institute of Technology

Creep of Metals at High Temperatures in Bending, by E. A. Davis, Westinghouse Research Laboratories

Behavior of a Bed of Plastic Clay Resting on Rock Surface, by B. K. Hough, Cornell University

Hydraulic

Round-Table Discussion on Cavitation

6:30 p.m. Dinner

Toastmaster: C. R. Soderberg, Westinghouse Electric & Manufacturing Co., Philadelphia, Pa.

Some Notes on the Work of the National Physical Laboratory, by H. J. Gough

Florida Engineering Society Holds Annual Meeting

THE twenty-first annual meeting of the Florida Engineering Society was held at the Hillsboro Hotel, Tampa, March 18–20. A business and four technical sessions were held during the days, and a smoker and entertainment on one evening and the annual banquet of the Society on another completed the program. A feature of the meeting was a luncheon on the opening day, at which members of the various national engineering societies gathered around special tables to hold business meetings of their respective local sections.

The opening and closing technical sessions were devoted to topics of interest to the civil-engineering profession, while the electrical and mechanical engineers each had a session of their own. The presiding officers at these sessions were all connected with the local section of their respective societies. At the mechanical-engineering session on March 19, J. P. Warren, chairman of the Florida Section of the A.S.M.E., presided, and the papers covered a variety of topics. The prize paper by a member of the University of Florida A.S.M.E. Student Branch was presented, and J. M. Todd, and E. W. O'Brien, vice-president and a past vice-president of the A.S.M.E., respectively, made some informal remarks. Excursions to a number of points of engineering interest in Tampa and the immediate vicinity were a feature of the meeting.

* To be presented by title only.

President James H. Herron to Speak at Graphic Arts Conference, New York

FINAL plans have been made by the A.S.M.E. Graphic Arts Division in cooperation with the Graphic Arts Research Bureau for the Graphic Arts Technical Conference to be held in New York, N. Y., May 6 to 8, with headquarters at the Hotel Commodore.

The program is an interesting one with inspection trips and technical sessions. At the luncheon on Friday, May 7, talks will be given by Dr. John E. Finley, editor of the *N. Y. Times*, James H. Herron, President of the A.S.M.E., and the Hon. A. E. Giegengack, Public Printer of the United States.

Registration will open on Thursday at 11:00 a.m. in the foyer of the West Ballroom of the hotel. There will be a registration fee of $3 to those not members of either of the sponsoring organizations. Tickets for the luncheon are $1.50.

The afternoon will be devoted to an inspection trip to the plant of R. Hoe & Company, where a demonstration will be given of high-speed newspaper unit printing and pasting—55,000 copies per hour. The manufacturing facilities of the company for the production of heavy-duty printing machines will also be open to inspection.

Thursday evening will be given over to an inspection of the *Daily News* plant where the various make-up departments may be seen and later the operation of the presses.

Technical sessions scheduled for Friday and Saturday are as follows:

FRIDAY, MAY 7

9:30 a.m.

Management Session

Chairman: John Clyde Oswald, Gregg Publishing Company.

Introductory Address by V. Winfield Challenger, Vice-President, G.A.R.B.

Employer-Employee Relations, by W. M. Passano, Treasurer, Waverly Press, Baltimore, Md.

Training in the Printing Industry, by J. H. Holloway, N. W. Printing School.

12:30 p.m.

Luncheon, East Ballroom

Chairman: A. E. Giegengack, Public Printer of the United States.

Speakers:

John H. Finley, editor, *N. Y. Times*.

James H. Herron, President, A.S.M.E.

2:30 p.m.

Color-Printing Progress Session

Chairman: W. C. Huebner, Huebner Laboratories, Inc.

Color Gelatine Printing, by Rudolph E. Fehse, Consolidated Film Industries

Color Offset Printing, by Herman A. Bernhardt, Latham Lithographic Company.

Color Rotogravure Printing, by M. R. Pellissier, Gravure Foundation.

Enclosed Ink Fountain for Gravure Printing, by Frederick W. Bender, manager, Alco-Gravure Division, Publication Corporation.

Evening Open

SATURDAY, MAY 8

9:30 a.m.

Paper and Printing Session

Chairman: R. G. Macdonald, Secretary, T.A.P.P.I.

Progress and Problems in Printing Rollers, by J. C. Dunn, Vulcan Proofing Company.

Progress and Problems in Rubber Plate Printing, by J. B. Shaughnessy, Rubber Printing Products Division of American Wringer Company.

Relationship Between Quick-Drying Inks and Paper, by Charles MacArthur, Reynolds Metal Company.

Actions of A.S.M.E. Executive Committee

A MEETING of the Executive Committee of The American Society of Mechanical Engineers was held in the rooms of the Society on March 20, 1937. There were present: James H. Herron, president; Harry R. Westcott, W. A. Shoudy, James W. Parker, and Kenneth H. Condit, of the committee; William T. Conlon and J. N. Landis, advisory members representing the Finance and Local Sections committees, respectively; and C. E. Davies, secretary. The following actions of general interest were taken.

Condit Appointed to U.E.T.

Kenneth H. Condit was appointed representative of the Society on the United Engineering Trustees, to fill the unexpired term of Walter Rautenstrauch, resigned.

Stevenson Appointed to E.C.P.D.

A. R. Stevenson, Jr., was appointed representative of the Society on the Engineers' Council for Professional Development to fill the unexpired term of W. L. Batt, resigned.

Recommendations of E.C.P.D.'s Committee on Professional Recognition Considered

The Committee considered and discussed a report by the A.S.M.E. Advisory Board on Professional Status dealing with the report of the E.C.P.D. Committee on Professional Recognition, published in MECHANICAL ENGINEERING, February, 1937, pages 135–136. This report was referred to the A.S.M.E. Advisory Board on Professional Status, and an excerpt from the Board's minutes of March

A.S.M.E. Calendar

of Coming Meetings

May 6–8, 1937
Graphic Arts Conference Hotel Commodore, New York, N. Y.

May 14–15, 1937
National Rayon Textile Conference, Wardman Park Hotel, Washington, D. C.

May 17–21, 1937
Semi-Annual Meeting
Detroit, Mich.

June 25–26, 1937
Applied Mechanics and Hydraulics Meeting
Cornell University

August, 18–21, 1937
Oil and Gas Power Meeting
Pennsylvania State College

October, 1937
Wood Industries Meeting
Grand Rapids, Mich.

October 15, 1937
Textile Meeting
Boston, Mass.

Local Sections Meetings
See page 396

11, 1937, at which the report was considered, is published on page 394 of this issue. The report of the E.C.P.D. committee made a number of recommendations regarding the registration of engineers, and, in particular, one which concerned the relationship of A.S.M.E. membership and qualifications for registration.

Following a study of the action taken by the A.S.M.E. Advisory Board on Professional Status, the Executive Committee voted to adopt the Advisory Board's recommendation to the effect that the report of the E.C.P.D. Committee on Professional Recognition be called to the attention of Society members through the senior councilors and the local sections, and that the E.C.P.D. be informed that the report of its committee is under consideration by the Society.

The Secretary of the Society was requested to make it clear in referring to the report that the E.C.P.D. has not yet adopted the report, and also to ask the E.C.P.D. not to commit the participating societies until the views of A.S.M.E. members can be canvassed.

Membership Status

The Committee voted: (1) To suspend distribution of publications to members owing all of the current-year's dues; (2) to drop from membership all those owing two years', or more, dues; (3) to extend to June 20, 1937, for members who owe current dues and partial dues for the previous year, the date before which they may make sufficient payment to come into good standing for the current year.

W. Lyle Dudley to Serve for Senior Councilor, Group VII

Because of the illness of John A. Hunter, senior councilor for Group VII, W. Lyle Dudley was appointed to take over the duties of this office during Professor Hunter's illness.

Erie and St. Louis Meetings Authorized

Meetings of the Society at Erie, Pa., during the week of Sept. 27, 1937, and at St. Louis, Mo., during the week of June 20, 1938, were authorized. The St. Louis meeting will be the 1938 Semi-Annual Meeting.

Special Committees Discharged

Two special committees of the A.S.M.E. Council, (1) on Prime Movers in Rotary Drilling of Oil Wells, and (2) on Automatic Oil-Pipe-Line Pumping Stations were discharged with thanks for their services.

Appointments

The following appointments were reported:
As representatives of the Council at the A.S.M.E. Student Conferences:

Providence, R. I., Brown University, April 23–24, H. R. Westcott.

New Brunswick, N. J., Rutgers University, April 19–20, W. A. Shoudy.

Columbus, Ohio, Ohio State University, April 26–27, J. H. Herron.

Chattanooga, Tenn., April 19–20, J. M. Todd.

Chicago, Ill., Northwestern University, April 19–20, A. D. Bailey.

Kansas City, Mo., Kansas State College, April 9–10, A. D. Bailey.

Stillwater, Okla., Oklahoma A. & M. College, April 5–6, E. W. Burbank.

Pullman, Wash., State College of Washington, April 19–20, W. Lyle Dudley.

Laramie, Wyo., University of Wyoming, April 23–24, J. W. Haney.

Stanford University, Calif., April 1–3, W. F. Durand.

To Safety Section Committees: Lighting Factories, Mills and Other Work Places, H. H. Judson; Safety Code for Exhaust Systems, Theodore F. Hatch; Safety Code for Power Presses and Foot and Hand Presses, J. B. Chalmers.

To the Daniel Guggenheim Medal Board, W. B. Mayor.

To the Hoover Medal Board of Award, S. F. Voorhees, reappointment.

To the Unwin Memorial Committee, F. L. Eidmann (to replace J. A. Hall, deceased).

President Herron to Visit New England Sections

The president of the Society, James H. Herron, is to make an automobile trip this spring to visit the northeastern sections of the A.S.M.E. Starting with the Schenectady Section in New York, President Herron will travel all through the New England States and to Montreal, Canada.

The meeting which he will attend at Waterbury, Conn., on May 27 will be the spring meeting of the Connecticut Local Sections.

His detailed itinerary follows:

May 24: Schenectady, N. Y., Section and Rensselaer Student Branch
May 25: Green Mountain Section, Springfield, Vt.
May 26: Western Massachusetts Section, Springfield, Mass.
May 27: Waterbury, Conn., Section (Spring Meeting of Connecticut Local Sections)
May 28: New Haven, Conn., Section
May 31: Hartford and New Britain, Conn., Sections
June 1: Norwich, Conn., Section
June 2: Providence, R. I., Section and Brown University Student Branch
June 3: Worcester, Mass., Section and Worcester Poly Student Branch
June 4–7: Boston, Mass., Section and M.I.T., N. E. University, and Tufts Student Branches
June 8: University of New Hampshire Student Branch, Durham, N. H.
June 11: University of Vermont Student Branch
June 15–18: Montreal, Canada.

With the Student Branches

Armour Institute had S. Miner present a talk on stokers illustrated by means of slides. H. L. Meyers gave a talk on railroad signals illustrated with miniature models. V. J. Jandasek's talk on hydraulic transmission was accompanied by a demonstration, of the principles involved, on an actual working transmission perfected by the speaker. The time and motion study paper by P. M. Reh was illustrated with motion pictures taken by Reh . . . . . At C.C.N.Y. Branch, interesting talks were given by Maxwell Zirin on superchargers, Harry Miller on the "Reynolds Number," Arthur Chiger on choice of metal-cutting fluids, George Kaplan on nondestructive testing, Herbert Steinman on the manufacture of corrugated paper, Joseph Branerman on sound control in air conditioning, Sol Lapidus on heating by refrigeration and Edward Palchik on high-speed indicators . . . . . Lisle Wilson entertained his fellow members at Colorado with motion pictures of the Boulder Dam furnished by the Bureau of Reclamation. Harvey Brown made an analysis of automotive lubrication systems which he presented in a paper. Frank Sabec traced the history and development of the Diesel engine and Roy Vorhees made a comparison of refrigerants . . . . . Cooper Union Branch members had an interesting discussion on the principles of heating

and air conditioning given by Robert A. Rankel . . . . . Papers were presented at a meeting of the IOWA STATE COLLEGE BRANCH by Robert Rae on streamlining and its relation to fuel economy, William Shoemaker on deriving a formula to determine the force necessary to punch mild-steel plates, and James Bryant on hydraulic transmissions . . . . . IOWA STATE UNIVERSITY BRANCH had a report by Sogge on lubricants in machine work, McCloy on the inspection of welds, Hudson on airplane superchargers and Heeren on efficiency of power plants . . . . . At LOUISIANA STATE UNIVERSITY BRANCH, Cooper gave an interesting talk on railroads.

More Talks by Student Members

LOUISVILLE BRANCH had George Ellsworth give a talk on the operation of the local gas and electric company during the recent flood. Witherspoon gave a talk on the method of keeping correct time, and W. H. Hood talked on the effect of longer gaps in automobile spark plugs . . . . . MICHIGAN BRANCH had several papers presented by members. Outstanding among them according to three judges were those of Fred Jennings on "A Millionth of an Inch," James Colovin on "Social Security," and Carl Van Loo on "A Household Stoker" . . . . . Interesting technical papers were presented at NEBRASKA by Harold Brown on the Abbott solar cooker, Ellis Smith on engineering photography, and Roger Wallace on the Britt method of carbonating water . . . . . At a meeting of the NEWARK COLLEGE BRANCH attended by 95 members, John R. Hopkins presented a paper on the topic of sound and noise prevention in engineering, R. D. Weigand spoke on highway safety, and F. B. Northrup talked on mineralogy . . . . Down at NORTH CAROLINA, the topic of highway safety was covered by J. A. Miller, the subject of heating by refrigeration was ably presented by A. P. Hyde, and lightweight Diesels were discussed by William P. Kephart . . . . NOTRE DAME BRANCH members heard about domestic stokers from Thomas Fitzgerald and the manufacture of steel ball bearings from E. J. Moore . . . . . At PRINCETON, M. C. Long presented a paper on a directional blade propeller designed by himself. . . . . TEXAS TECH had a joint paper presented by Henry Meredith and Jim Kelley dealing with the effect of burner design on the combustion of natural gas . . . . . A TORONTO BRANCH member, Ian M. Hamer, was asked to give his paper on "Airplane Skiis," presented at an earlier branch meeting, before the Junior Section of the Ontario Section . . . . . TULANE BRANCH listened to talks by Donald Jahncke on recent innovations in automotive design and by R. B. James on recent trends in locomotive design . . . . . GEORGE WASHINGTON UNIVERSITY BRANCH had papers presented by L. J. Dawson on hydraulic transmissions, by A. P. Dean on fuel pulverization and by R. F. Muth on smoke prevention . . . . . WASHINGTON STATE COLLEGE BRANCH elected George Grant to fill the vacant position of vice-chairman and Jack Wetzel as secretary. George showed his appreciation by giving an interesting talk on the construction of the Grand Coulee Dam based on his own experiences while working on the dam last summer and fall.

Guest Speakers

NEWARK COLLEGE BRANCH in continuing its series of talks on various subjects had E. V. Erickson of the Carrier Engineering Corporation give a talk on air conditioning . . . . . W. E. Colley discussed the Kingsbury thrust bearing before the C.C.N.Y. BRANCH . . . . . J. Staniar explained the method of choosing a correct mechanical transmission to the members of DELAWARE BRANCH . . . . . Prof. T. R. Thoren of the STATE UNIVERSITY OF IOWA gave a very interesting lecture before the branch on the performance of automobile fuels on the test block and on the road . . . . . LAFAYETTE BRANCH had A. Warren Canney, designer of the air-conditioning systems in Radio City, give a talk on his work . . . . . M.I.T. BRANCH paid a visit to China on the words of Lt. Commander J. G. Manning, U. S. Navy who spent some time in that far-off land . . . . . A very timely topic, labor relations, was given before the MICHIGAN STATE BRANCH by A. Clark, manager of labor and public relations for the U. S. Rubber Co. . . . . . A. Butler gave a very interesting discourse before the MICHIGAN BRANCH on Diesel-electric transportation . . . . . MISSOURI BRANCH welcomed back Gene Burnette, a former member, who talked on the sidelights of air conditioning . . . . . NEW HAMPSHIRE BRANCH members heard a lecture by Phillip M. Perry on ethyl gasoline . . . . . Dean Woolrich of the UNIVERSITY OF TEXAS talked to the members of NORTH CAROLINA BRANCH on the subject of engineering economics as applied in the South . . . . . Professor Bowers spoke on social security and unemployment insurance before the members of OHIO STATE BRANCH . . . . . PENN STATE BRANCH had a turnout of over 172 members and visitors to listen to Alan Howard of the General Electric Company give an illustrated lecture on problems encountered in a mercury-vapor power plant . . . . . PITTSBURGH BRANCH had Lewis Ensley, a member of the engineering faculty of the UNIVERSITIES OF PITTSBURGH and PURDUE, speak on railway-train brakes. At another meeting, the members obtained a great deal of advice in a talk by C. S. Coler on the graduate's adjustment to an industrial organization . . . . . At a meeting of PURDUE BRANCH, attended by over 350 members and visitors, W. D. Bearce spoke about Diesel-electric locomotives and streamlining . . . . . U.S.C. BRANCH saw a film on alloy steels presented and discussed by Mr. Stetter of the Bethlehem Steel Corporation . . . . . TEXAS BRANCH heard an interesting talk by David L. Fiske entitled "Boy Against the Book" . . . . . TEXAS A. & M. BRANCH reports that over 150 members and visitors listened to an illustrated lecture on Diesel engines by Harte Cook . . . . . VILLANOVA BRANCH was addressed by Mr. Harrison on the subject of Diesel power . . . . . WORCESTER POLY learned a great deal from a talk on "The Physicist as an Engineer" by Prof. R. A. Beth.

Trips and Inspections

AKRON BRANCH members visited the Campbell works of the Youngstown Sheet and Tube Company . . . . . Members of C.C.N.Y. BRANCH located in New York visited several plants in the vicinity of Pittsburgh during the Easter vacation . . . . . NEW HAMPSHIRE inspected the Lynn, Mass., plant of the General Electric Company . . . . . David D. Eames, designer of the Newton Water Pump Works, conducted a group from NORTHEASTERN through the works . . . . . The PRINCETON BRANCH sponsored a trip, open to other students to the plants of the Palmolive-Peet Co. in Jersey City and the Carrier Corporation in Newark . . . . . RICE BRANCH made an inspection of the *M S Dallas City* of the Reardon Smith Line which was built in England last year . . . . . The Hayden Planetarium was visited by members of STEVENS BRANCH . . . . . A joint trip was undertaken by TULANE and LOUISIANA STATE BRANCHES to a cement factory and a power plant . . . . . Emil Mathias, corresponding secretary of VILLANOVA, reports a trip undertaken by the branch to the Baldwin Locomotive Works in Eddystone, Pa. He says, "The trip was very instructive to all and VILLANOVA students were found crawling out of Diesel engines and locomotive boilers and pistons all afternoon." Really? . . . . COLORADO BRANCH inspected the plants of a fuel and iron company, a refrigerating company and the air-conditioning system of a motion-picture theater . . . . . From last reports, MISSOURI BRANCH was planning a trip to St. Louis.

Joint Meetings

A joint meeting and dinner was held by the student branches of the A.S.M.E. and the A.I.E.E. of the UNIVERSITY OF MISSOURI . . . . . TEXAS BRANCH mentions a joint meeting held with TEXAS A. & M. and RICE . . . . . AKRON BRANCH held a joint meeting with the Akron-Canton Section at which the program was dominated by the students. John Martin spoke on the cooperative plan at the university, F. A. Brubaker followed with a paper on cementing materials and Donald Cornell closed the meeting with an interesting talk on the different types of wire-drawing machinery . . . . . At NEW MEXICO, the A.S.M.E and A.S.C.E. branches conducted a joint meeting. The M.E.'s were represented by Gerald Monihan who talked on air conditioning.

Texas Holds Dance in Heat Lab

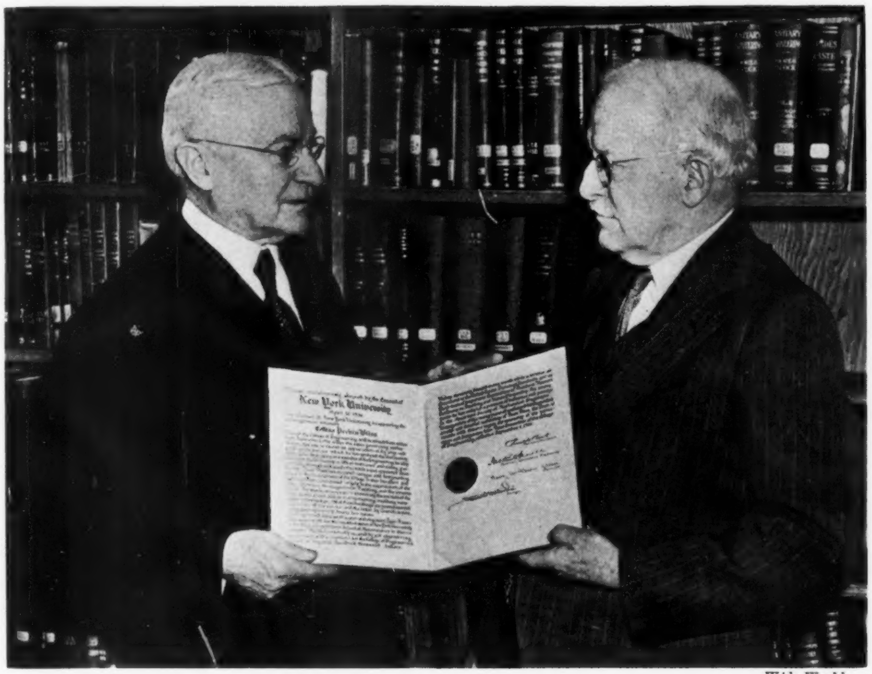
The members of TEXAS BRANCH, following the example of WASHINGTON STATE, held a dance in the heat laboratory of the mechanical-engineering department.

Texas A. & M. Raises Money

The TEXAS A. & M. BRANCH sponsored a benefit picture show at the campus theater from which they realized a very sizable profit to be used to help defray expenses of the regional conference to be held there in 1938.

Contest for Regional Representatives

At a contest held by the University of Colorado to select two representatives to attend the Regional Meeting of the Student Branches at Laramie, Wyo., Braford E. Bailey and Edward V. Garnett were chosen with Carl A. Moore as alternate. Mr. Bailey's talk was entitled "Inspection of Refinery Equipment." Mr. Garnett's paper was on "Dual Front-Wheel Mountings for Busses, Trucks, and Other Heavy Vehicles." Mr. Moore's paper dealt with "Cement Guns and Gunite."



Wide World

DEAN EMERITUS COLLINS P. BLISS (RIGHT), FOR WHOM THE NEW BUILDING WAS NAMED, RECEIVING A SCROLL FROM ARTHUR S. TUTTLE, CHAIRMAN OF NEW YORK UNIVERSITY'S COUNCIL COMMITTEE ON ENGINEERING

N. Y. U. Dedicates Bliss Building

Collins P. Bliss Honored at Dedicatory Ceremony and Luncheon

A DISTINGUISHED group of engineers, scientists, and educators witnessed, on April 3, at New York University, the dedication of a recently completed engineering building and power plant at New York University named in honor of Collins P. Bliss, dean emeritus of the College of Engineering and member The American Society of Mechanical Engineers. Tributes to Dean Bliss were paid by Chancellor Harry Woodburn Chase and Dean Thorndike Saville, of New York University, at the dedicatory ceremony which took place in the library of the Bliss building and Arthur S. Tuttle, chairman of the University's Council Committee on Engineering and past-president, the American Society of Civil Engineers, reviewed Dean Bliss's career and presented him with a scroll on behalf of the University's Council.

The new laboratory dedicated to Dean Bliss is a three-story structure in the basement of which is a combination steam and Diesel-engine power plant which furnishes steam for heating the University Heights buildings of the University and electricity for lighting and power. Hydraulics, materials-testing, and cement-testing laboratories are housed in the Bliss building, as well as a meteorological laboratory, drafting room, classrooms, offices, and an engineering library.

At a luncheon following the dedicatory ceremony, at which Chancellor Chase presided, Harvey N. Davis, president, the Stevens Institute of Technology, and chairman of the A.S.M.E. Committee on Meetings and Program, spoke of the friendly qualities of Dean Bliss's character that have so endeared him to students and associates, and of his many services to The American Society of Mechanical Engineers, including his chairmanship of the Society's Standardization and Meetings and Program Committees.

Tribute to Dean Bliss's initiative and foresight in establishing at New York University a course in applied meteorology was paid by Willis R. Gregg, chief of the United States Weather Bureau. This course, which is one of the first if not the first to be offered by an American university, was the outgrowth of needs developing from the work in aeronautics carried on at the Daniel Guggenheim School of Aeronautics at New York University. It was under Dean Bliss's leadership that courses in aeronautics were set up at New York University, and it was his enthusiasm that interested the late Daniel Guggenheim in establishing schools of aeronautical engineering throughout the country. The laboratory at New York University was the first to be built with the Guggenheim fund.

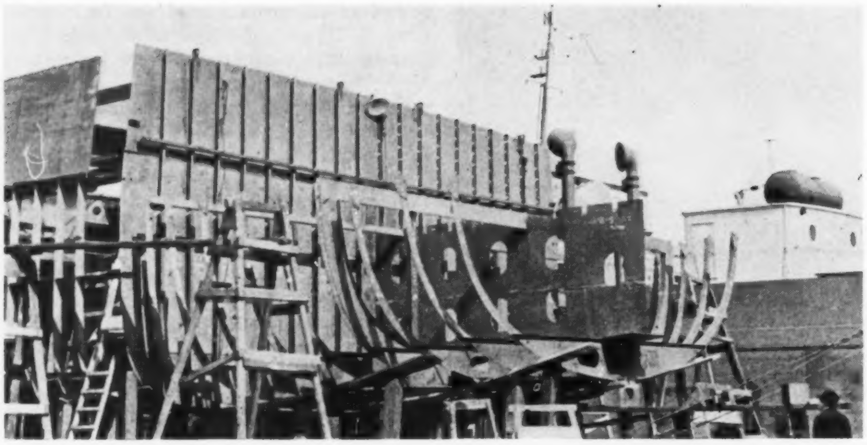
Observations of meteorological conditions are made at New York University by plotting the courses of balloons released from the laboratory which has been designated an Upper Air Station of the Federal Weather Bureau and which is in communication with the Newark Air Port and Floyd Bennett Field. The new course in applied meteorology is conducted by Prof. J. Edmund Woodman, with whom is associated as special lecturer the distinguished meteorologist James H. Kimball, of the New York Weather Bureau, whose knowledge of weather conditions over the North Atlantic has been of inestimable value to pioneer aviators in making flights between this country and Europe.

As a tribute from his associates of the College of Engineering, Dean Bliss was presented a combination radio and phonograph. Prof. Douglas S. Trowbridge, who spoke for his colleagues in presenting the gift, displayed a framed photograph of Dean Bliss to be hung in the Library of the Bliss building.

In response to the speakers who had preceded him, Dean Bliss spoke of his forty years' association with the University and of the satisfactions it had been to him. He announced that he planned actively to promote the raising of funds for the newly established course in applied meteorology at New York University and to continue his duties as president of the Engineering Index, Inc. Late in April he and Mrs. Bliss will leave for an extensive trip to Europe, which will include a visit to Roberts College, Constantinople, where his son is teaching engineering subjects.

Wide World

THE BLISS BUILDING—ENGINEERING SCHOOL AND POWER PLANT



DIESEL-POWERED GEAR-REDUCTION-DRIVE BOAT UNDER CONSTRUCTION AT THE GREAT LAKES ENGINEERING WORKS

(View shows end of ship ready for bow. Boat will be 300 ft long, 43 ft wide, and 2200 tons capacity. It is being fabricated from all-welded steel sections and when finished will be used by the Ford Motor Company in Great Lakes service.)

Junior Group of Detroit Inspects Great Lakes Engineering Works

JUNIOR members of the Detroit Section of the A.S.M.E. enjoyed an inspection trip on Saturday morning, March 27, through the plant of the Great Lakes Engineering Works, shipbuilders.

Of particular interest were methods used for machining and fabricating large structures for few have ever seen such large equipment as their "rigging loft," or the huge bending table and heat-treat furnace. The traveling-head planer also came in for its share of inspection.

A fine opportunity was presented to the visiting group to see the details of ship construction as shown by two welded steel boats being fabricated for the Ford Motor Company. The working of the dry dock was explained and its operation watched. The accompanying illustration shows the end of one of the ships ready for the bow.

The all-weld type of ship is a new type of construction, it was pointed out, having been developed within the last ten years. No rivets are used in the entire construction and this reduces the weight of the ship approximately 15 per cent. It also enables the fabrication of sections in an inside shop, the finished sections being hoisted into place with cranes. Ships will have a cargo capacity of 2200 tons and will have maximum speeds of $11^1/_2$ knots. Because they will be used on canals as well as on the Great Lakes, they are equipped with telescoping pilot houses which can be retracted while traveling under bridges. Each boat will carry a crew of 22 men. The cost will be approximately $450,000 a ship, and they are to be ready for service about June 15 of this year.

The trip through the engine room and hold of the *Calcite* rounded out the trip and made it one of the most popular of the year.

Another particularly successful meeting held by the Group was the inspection trip which they made in December to the Ford Glass Plant and which was attended by over fifty members.

In February the Junior Group held its first "Ladies Night." Supper was served to fifteen couples and all attended the broadcast of the "Ford Sunday Evening Hour."

First Year of Junior Group of Ontario Section a Success

AS THE first year of operation of the Junior Forum of the Ontario Section of the A.S.M.E. comes to a close, it reports a membership of 35, and an active and varied program which it feels was a contribution to the work of the Section itself. Recent graduate student members have been encouraged to take part in its activities and programs have been arranged to cover many interests.

One of the early meetings was addressed by an A.S.M.E. member, O. E. Ellis, of the Ontario Research Foundation, on "Failure of Metals in Service" and was followed by a round-table discussion.

At another A. R. Davis, Jun. A.S.M.E., of the Automatic Electric Sales Company, explained with the aid of a display of apparatus various methods of industrial controls.

The manager of the apparatus division of the Canadian General Electric Co., Ltd., G. S. Stewart, was a dinner speaker at a later meeting and took for his subject "Sales Engineering," which he illustrated with a motion picture of electrical manufacture.

On March 24 papers were presented on "Modern Air-Conditioning Practice" by H. G. Gill, E. V. Bowerman, E. A. Dowler, and H. K. Kerr, all members of the Junior Forum. The official Student Branch delegate to the Spring Conference, I. M. Hamer, also presented his paper on "Airplane Skids." All graduating members of the Student Branch of the University of Toronto were guests at a dinner which preceded this meeting.

Over 100 Attend Hartford and Providence Junior Group Meeting

UNDER the sponsorship of the Hartford Junior Group of the A.S.M.E., a successful joint meeting with the Providence Junior Group was held at Hartford, Conn., on March 6. Over 100 young men from various parts of Connecticut and Rhode Island, including students from Brown University and Connecticut State College, attended. The program included a visit to the plant of the Pratt & Whitney Division of the Niles-Bement-Pond Company in the morning, a luncheon, and an afternoon session, at which W. L. Batt, past-president of the A.S.M.E., was the principal speaker.

Richard Shaw, chairman of the Hartford Junior Group, opened the session. A series of six addresses by Gordon Phillips, Harold Sizer, and Herbert Anderson, of Providence; and James Tasillo, Frank Hale, and Peter de Bruyn, of Hartford, followed, in which each speaker described the activities in his group.

The principal speaker of the afternoon, W. L. Batt, past-president of A.S.M.E., emphasized the benefits of the junior engineering movement to the individual and the profession. One point brought out in his address was that frequent self-appraisement, continued study, and willingness to work for professional and individual development cannot fail to open the eyes of the young engineer to the opportunities which are his. Another was that the crying need for active interest in public affairs by men possessing engineering training, as contrasted with those who have been educated for the legal profession, will be met by the junior engineer of today who will be the engineer of tomorrow.

Prof. C. F. Scott, of Yale University, chairman of the Engineers' Council for Professional Development and past-president of the American Institute of Electrical Engineers, followed Mr. Batt and mentioned events in his professional life, which were seemingly unimportant when they occurred but subsequently proved instrumental in present engineering development. In his opinion, future professional standards, which are now being set by the ideals, energy, and enthusiasm of young men, are merely a continuation of the youthful efforts of those men who are now our professional leaders. An interesting discussion of the aims of the Providence Junior Group by Robert Anthony, Jr., its chairman, concluded the meeting.

The committee in charge of the arrangements for the meeting consisted of R. D. Keller, chairman, D. G. Ferry, H. S. Foster, G. E. Leitch, N. B. Record, and G. T. Spicer.

(*Continued on page 394*)

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Other Engineering Activities

The E.C.P.D. Recognition Report Referred to A.S.M.E. Members

At a meeting of the Advisory Board of Professional Status held on March 11, 1937, a report[1] of the Committee on Professional Recognition of the Engineers' Council for Professional Development was discussed. The following excerpt from the minutes of the A.S.M.E. Advisory Board on Professional Status summarizes the Board's recommendations on the report.

The Board reached the conclusion that this report[1] should be called to the attention of the Executive Committee with the suggestion that it be referred to the senior councilors and the individual local sections and that it be discussed at the Sections' Conference in Detroit; that the discussion at this conference be referred to the Board on Professional Status for review and recommendation to the Executive Committee for further action.

The Advisory Board on Professional Status adopted the following statement to be sent to the local sections as a basis for their discussion and consideration:

The Engineers' Council for Professional Development has an important committee, that of Professional Recognition, to which is assigned the problem of developing procedure and recommendations for bringing some correlation into the various methods of formal recognition of the development of the engineer. The present stages of recognition are: professional education, registration as a professional engineer, membership in a professional grade of a recognized engineering society.

The report of the Committee on Professional Recognition appeared on pages 135 and 136 in the February issue of MECHANICAL ENGINEERING and merits careful study by every member of the Society.

One recommendation in that report is of particular importance to the administration of the Society, that is, recommendation No. 5, that "state registration of a candidate be established as a minimum prerequisite for admission to professional grades of membership with such provisional exceptions as present circumstances may justify." This matter has been given painstaking consideration by the Advisory Board on Professional Status. This board points out: (1) That the registration of engineers has been adopted as a means of recognition by 35 states; (2) that the Society must establish its own prerogatives and qualifications on a national basis; (3) the Society should not exclude the qualified engineer who is engaged in engineering work not requiring that he shall possess a license. In view of the foregoing, the Board suggests the following statement of policy for discussion and adoption by the Society as a guide to the Committee on Admissions in scrutinizing the qualifications of candidates for membership: "Whereas no one can now say when, if ever, all men qualified for membership in A.S.M.E. will desire or, alternatively, be required to obtain a state license to practice professional engineering, state registration of a candidate or equivalent qualifications should be established as one of several minimum prerequisites for admission to professional grades of membership in the Society."

[1] "E.C.P.D. Committee on Professional Recognition," MECHANICAL ENGINEERING, February, 1937, pages 135–136.

A New Power Show for Mid West at Chicago, October 4 to 9

A NEW Power Show for the Mid West, the Chicago Exposition of Power and Mechanical Engineering, has been announced. The Exposition will be held October 4 to 9, 1937, at the New International Amphitheater in Chicago. It will be under the management of the International Exposition Company which has successfully conducted the National Exposition of Power and Mechanical Engineering which is held every two years in New York.

The Exposition will bring to the Middle West a comprehensive exposition of machinery, apparatus, and instruments used in generation of power, its control, transmission, and use; also the most up-to-date mechanical-engineering equipment designed to use power in the improvement of products and operation. Principal classifications of exhibits will include the following: combustion, electric-power generation and transmission, hydraulic, control, insulation, mechanical-power transmission, materials handling, plant maintenance, and prime movers, including steam, gas, oil, and Diesel engines.

Charles F. Roth, vice-president of the International Exposition Company, will be the manager of the Chicago Exposition of Power and Mechanical Engineering and all matters of contract and arrangements will be under his personal direction.

Milan Fair International Aircraft Exhibition, Oct. 2–17, 1937

THE Second International Aircraft Exhibition will be held in conjunction with the Milan Fair, October 2 to 17, with the purpose of making possible a complete picture of what is being done in this field throughout the world, and of helping the development of commercial and industrial business relations.

The exhibit will cover aircraft of all types and sizes, engines, spare parts, manufacturing materials, equipment and plans for hangars, outfits for aviators, graphic representation of passenger and mail transportation, aeronautical publications, maps, airmail stamps, and sundry material.

Applications for entry should be made July 1, 1937, to the Second International Aircraft Exhibition, Milan Fair, Milan, Italy.

Gear Manufacturers to Meet, May 24–25

MAY 24 and 25 have been chosen by the American Gear Manufacturers Association for its twenty-first annual meeting which will be held at the Galen Hall Hotel, Wernersville, Pa. In addition to an address by E. S. Sawtelle, president of the association, the program includes papers dealing with materials for and applications of gears, plant management, wage incentives, foremen's training, and credit unions.

Boiler and Pressure-Vessel Inspectors to Meet

THE eleventh general meeting of the National Board of Boiler and Pressure Vessel Inspectors will be held at the Hotel McAlpin, New York, N. Y., May 24, 25, and 26. This Board was organized in 1919 for the purpose of securing uniform approval of specific designs of boilers and pressure vessels through the adoption by various states and cities of one code of rules and of one standard stamp to be placed on boilers and pressure vessels constructed in accordance with such rules.

There will be morning and afternoon sessions on each of the three days. All of the sessions will be open to those interested; registration will be required but there will be no charge therefor.

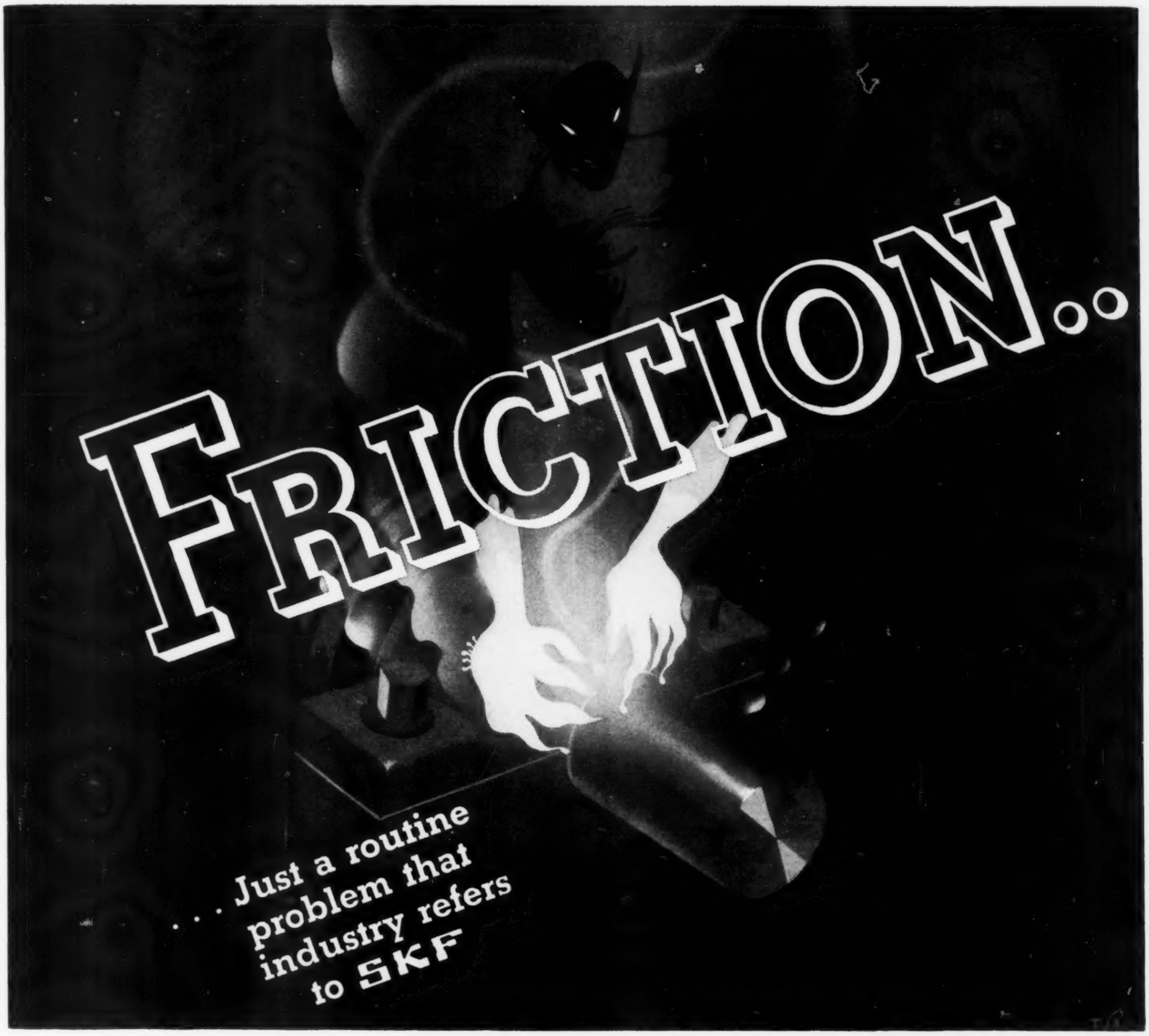
Economics Conference for Engineers at Stevens Camp, June 18–26

THE seventh Economics Conference for Engineers, that is given each year by Stevens Institute of Technology, will be held at its camp for engineers, Johnsonburg, N. J., June 18–26. Four courses on industrial management, course content and teaching methods, industrial economics, and industrial psychology will be given in the morning with eight lectures in each. D. S. Kimball and W. D. Ennis, past-president and treasurer, respectively, of the A.S.M.E., will give the lectures on industrial economics, each taking half of the course.

A series of evening forum meetings will be held with a lecture on some outstanding topic by a prominent speaker. One of these lectures will be delivered by R. E. Flanders, past-president of the A.S.M.E., who will speak on "Fundamental Changes in Our Economy." A general discussion will follow each lecture.

Concurrently with the conference, the Society for the Promotion of Engineering

(*Continued on page 396*)



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SKF
BALL AND ROLLER BEARINGS

Education will hold a summer session on the study of economics in engineering colleges. Members of the Stevens Conference will be welcome at any of the lectures arranged for these sessions, and both groups are particularly expected to participate in the evening lectures and discussions.

Further information regarding the Conference and the S.P.E.E. program may be obtained by writing H. N. Davis, president, Stevens Institute of Technology, Hoboken, N. J. Those planning to attend the Conference are urged to enroll as early as possible.

Local Sections

Coming Meetings

Akron-Canton: May 13. Timken Roller Bearing Company, Canton, Ohio, at 7:30 p.m. Subject: "Large Anti-Friction Bearing," by S. M. Weckstein, Timken Roller Bearing Company, Akron, Ohio.

Knoxville: May 18. All-day meeting at Kingsport, Tenn. This will be the Annual Meeting of the Knoxville Section with technical papers presented.

Minnesota: May 7. Joint evening meeting of the Minnesota Section and Student Branch at University of Minnesota. Subject: "Building a Profession: (*a*) The Progressive Program of Engineers' Council for Professional Development to Enhance the Professional Status of the Engineer; (*b*) The Responsibility of the Individual Engineer in This Program," by C. E. Davies, Secretary, The American Society of Mechanical Engineers.

Milwaukee: May 12. Wisconsin Club at 8:00 p.m. Joint Meeting of the A.S.M.E. Milwaukee Section, Milwaukee Engineers' Club, and Student Group of Marquette University. Subject: "Building a Profession," by C. E. Davies, Secretary, The American Society of Mechanical Engineers.

San Francisco: May 6. Golden Gate Bridge inspection. Tentative arrangements call for assembly at 4 p.m. at the Marina Boulevard approach to the Palace of Fine Arts. The group will return for dinner at the Engineers' Club at 6:00 p.m. The evening program will will be held in the Pacific Gas and Electric Company's auditorium, 245 Market Street and will start promptly at 7:45 p.m. Subjects: "Design and Construction of Golden Gate Bridge," by Charles E. Derleth, consulting engineer for the Golden Gate Bridge; "Approaches to the Golden Gate Bridge," by John H. Skeggs, division engineer, California State Highway Commission. Final details will be mailed later to each member.

Washington, D. C. May 13. Potomac Electric Power Company's auditorium at 8:00 p.m. Subject and speaker to be announced later.

Waterbury: May 20. Annual Ladies' Night Meeting, Elton Hotel. Subject: "Engineering of the Home of Tomorrow," by J. W. Clarke, Westinghouse Electric & Manufacturing Co.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after May 25, 1937, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers at once.

In addition to the names given are a group of approximately 2200 transfers from Student to Junior membership, whose names will appear on a May ballot to Council.

NEW APPLICATIONS

ABEL, STEPHEN TAYLOR, Birmingham, Ala.
ARMSTRONG, PAUL L., Los Angeles, Calif.
BONNELL, JOHN R., Chicago, Ill. (Re)
BOWEN, G. W., Whittier, Calif.
CANTRELL, P. C., Los Banos, Calif.
COOK, CHESTER KLING, Yreka, Calif.
DE FOREST, M. G., Rye, N. Y.
DI DONNO, PETER A., Hamden, Conn.
ELLIS, WILLIAM, Newark, Ohio
EVANS, ROBERT G. N., Toledo, Ohio
FORSYTH, STUART L., Rochester, N. Y.
FOX, CHARLES S., East St. Louis, Ill.
FRENCH, GEORGE E., Westfield, N. J.
GALLINI, EMIL, Detroit, Mich.
GOTMAN, E. V., New York, N. Y.
HAAS, EDGAR J., JR., New Orleans, La.
HANGARTNER, M. J., Casper, Wyo.
HAPPEL, HERMANN E., Toledo, Ohio
HODGE, BYRON T., Dayton, Ohio
HOLTZMAN, WILLIAM P., Chicago, Ill.
IVINS, MAURICE H., Chambersburg, Pa.
KRAMER, WILBUR C., Chicago, Ill.
LEYDA, HARRY LOUIS, Franklin, Pa.
MACHENRY, RICHARD, Charleston, W. Va. (Re)
MASTERS, H. W., JR., San Francisco, Calif.
McGIVERN, PROF. JAMES G., Pullman, Wash.
MILLER, ROLLA LEONARD, Arcadia, Calif.
MONEY, R. H., Russellville, Ky.
NORMAN, B. F., JR., Freeport, Tex.
OWEN, A. S., London, England
PETERS, H., Cambridge, Mass.
PROESCHOLDT, WALTER H., Cedar Rapids, Iowa
PROSIN, LOUIS, Los Angeles, Calif.
RENNER, WILLIAM E., Schenectady, N. Y.
RICHARDSON, ROBERT G., Greensboro, N. C.
RITTERBUSCH, HARRY F., Hoboken, N. J.
ROPER, EDWARD H., New York, N. Y.
SANDMANN, EUGENE, East Chicago, Ind.
SCHENK, J. M., Prospect Park, Pa.
SCHICKLER, EUGENE, San Francisco, Calif.
SCHICKEDANZ, S. A., Danville, Ill.
SCHROEDER, WALTER, Cincinnati, Ohio
SIMPSON, HENRY A., New York, N. Y.
SOUTHERLAND, THOMAS C., Brooklyn, N. Y.
STRASSMAN, ROBERT C., Milwaukee, Wis.
TWINING, F. E., Fresno, Calif.
VANDERBILT, DONALD H., New York, N. Y.
VON FISCHER, WALTHER C., Beloit, Wis.
WEISBERGER, ARTHUR A., Hammond, Ind.
WYATT, CHARLES C., San Francisco, Calif.
YAMANOUCHI, K., New York, N. Y.
ZITLAU, WALTER A., Ajo, Ariz.

CHANGE OF GRADING

Transfer from Junior

FAIRBANKS, C. M., Swarthmore, Pa.
HILL, ARTHUR L., Denver, Colo.
HITCHCOCK, JOHN H., Worcester, Mass.

Transfer from Member

ARNSTEIN, KARL, Akron, Ohio

Necrology

THE following deaths of members have recently been reported to the office of the Society:

ANDREW, JAMES D., March 22, 1937
AUEL, CARL B., April 4, 1937
BARR, JOHN H., SR., March 27, 1937
BURRELL, EDWARD P., March 21, 1937
CARPENTER, HENRY A., March 5, 1937
CUTTING, FREDERICK S., March 13, 1937
HYMAN, DAVID, March 23, 1937
VOORHEES, GARDNER T., March 18, 1937

A.S.M.E. Transactions for April, 1937

THE April, 1937, issue of the Transactions of the A.S.M.E., which is the *Journal of Applied Mechanics*, contains the following papers:

The Prevention of Failures of Surface-Condenser Tubes (FSP-59-2), by R. E. Dillon G. C. Eaton, and H. Peters
Analysis and Tests on Hydraulic Circuits of Surface Condensers (FSP-59-3), by G. H. Van Hengel
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